# United States Patent [19]

**Shurygin et al.**

[11] **3,885,906**

[45] **May 27, 1975**


[54] **CYCLONE FURNACE**


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[51] **Int. Cl.** ..... **F23c 5/18**

[58] **Field of Search** ..... 431/173, 5; 110/28 F, 8 R, 110/8 C, 7 B, 75



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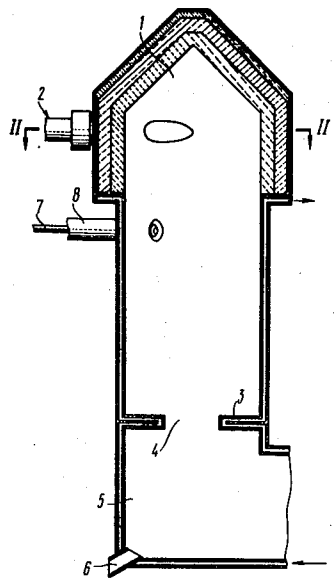
*Primary Examiner*—Edward G. Favors



[57] **ABSTRACT**

A cyclone furnace for incinerating industrial waste material containing organic or both organic and mineral components comprises a vertical cylindrical chamber with burner means arranged tangentially to its walls in its upper portion to supply fuel and air to the chamber and with fluid waste atomizers arranged transversely of the chamber under the burner means and combined with the nozzles for supplying air. An orifice is provided in the bottom of the chamber to connect the latter with the gas duct for removing combustion products, the gas duct having a tap for letting out fused mineral salts.


**5 Claims, 6 Drawing Figures**



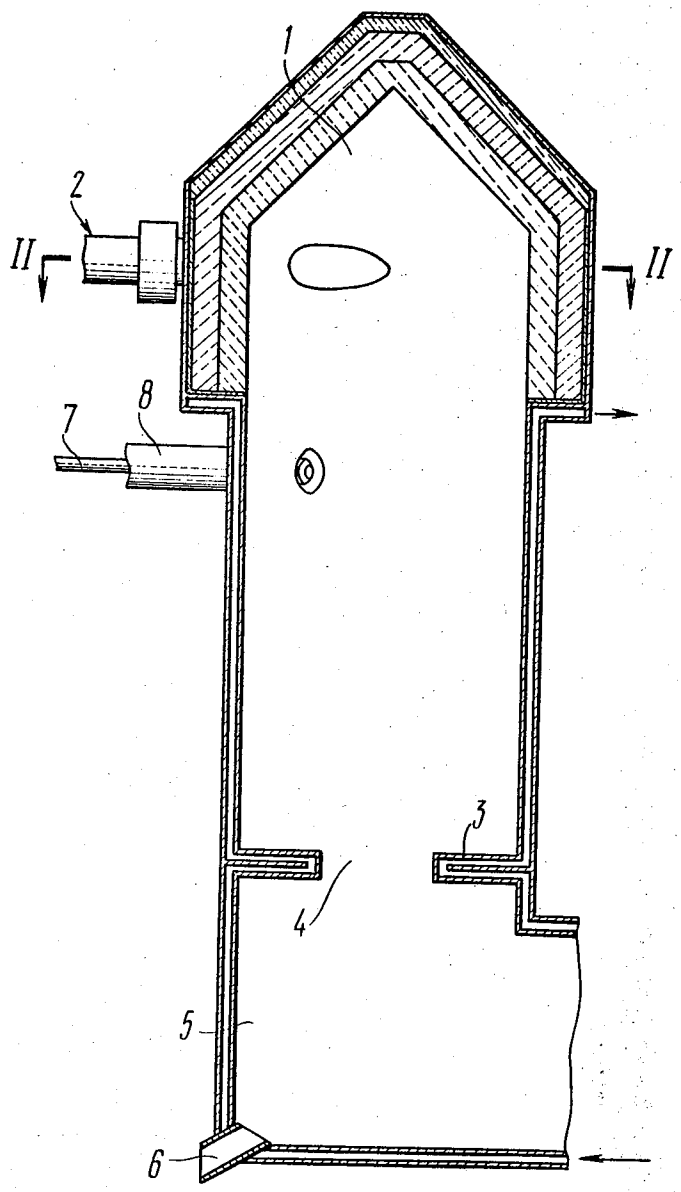



FIG. 1

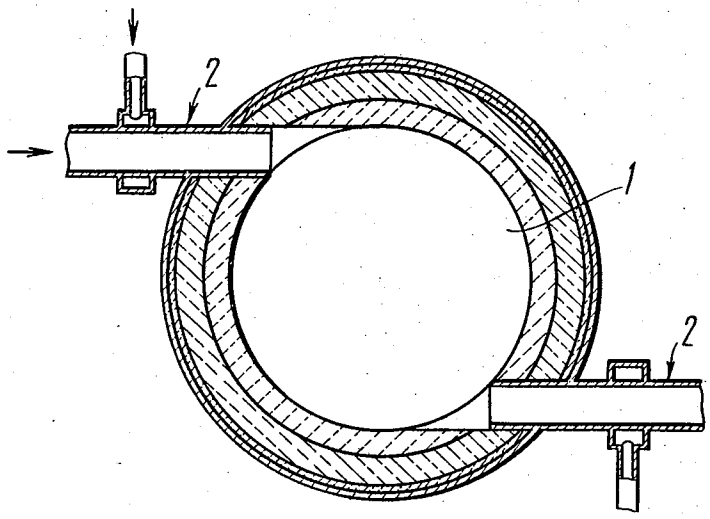



FIG. 2

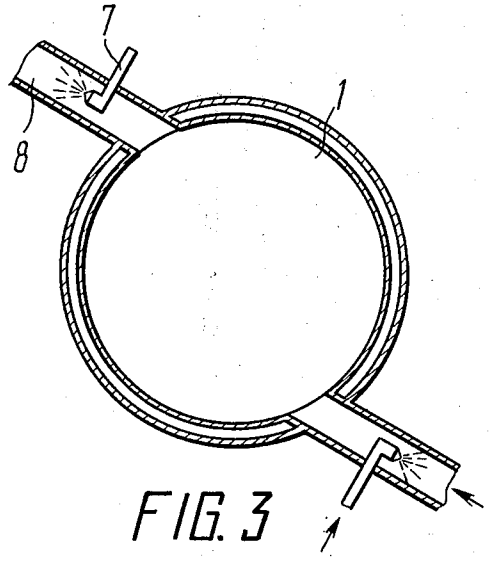



FIG. 3

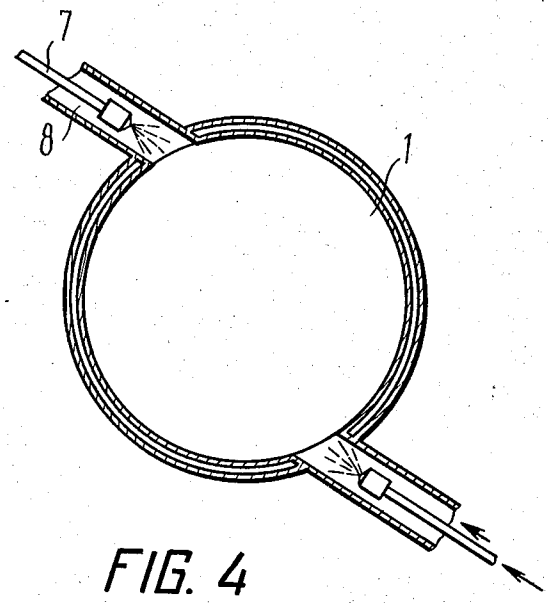



FIG. 4

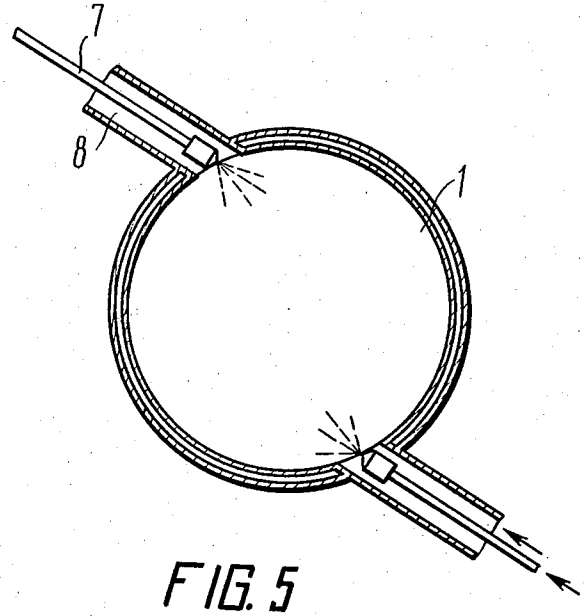



FIG. 5

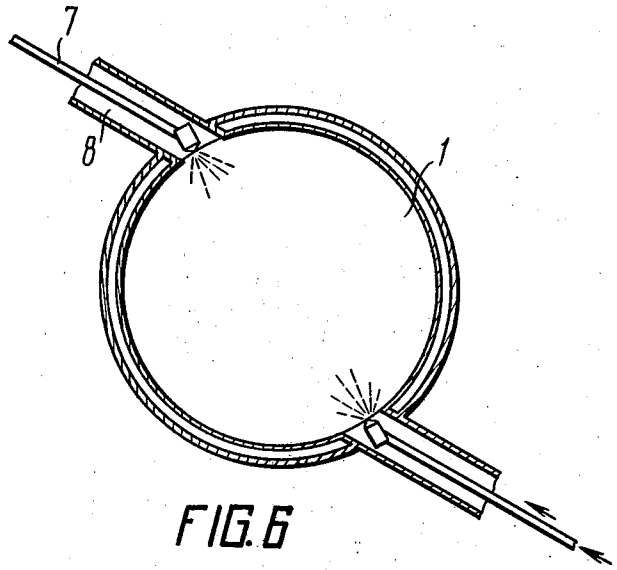



FIG. 6

# CYCLONE FURNACE

The invention relates to the equipment for disposal of various industrial waste materials with a view to eliminating pollution of the environment, and particularly to cyclone furnaces for incinerating fluid industrial waste material containing organic or both organic and mineral components.

The cyclone furnace of the present invention can most advantageously be used for incinerating industrial waste, i.e. by-products of chemical, petrochemical, pulp-and-paper, pharmaceutical and other industries.

A number of widely used waste disposal processes (chemical and biochemical) are known which more often than not fail to yield positive results. It is especially difficult to purify industrial effluents with a great variety and high content of organic and mineral components. Many such components in industrial waste are toxic for microorganisms and cannot be treated by biochemical processes. To dispose such effluents, incinerators of various designs are widely used.

Cyclone furnaces are by far the most universal effective devices for incinerating fluid industrial waste.

Cyclone furnaces are particularly efficient when used at chemical plants, for incinerating fluid waste containing various highly concentrated toxic organic and mineral components, in which case biochemical purification involves repeated dilution of the waste with pure water and is thereby rendered uneconomical.

A cyclone furnace for incinerating fluid industrial waste is known which comprises a vertical cylindrical chamber whose geometry depends on the chemical composition of components in the waste and on the furnace capacity. The upper portion of the chamber is made from refractory and insulating brick and provided with a conical, flat, or dome-shaped cover. Tangentially arranged in the upper portion of the chamber and circumferentially distributed are short-flame burners for supplying fuel and air required for the combustion of the organic components of both waste and fuel. The brick lining in the upper portion of the cyclone furnace chamber serves as a good stabilizer for fuel burning.

Located under the upper portion of the cyclone furnace chamber is a working chamber terminating at the bottom in a circular orifice which makes the water-cooled and garnissage-lined operating chamber communicate with the gas duct for removing the combustion products and fused material. The working chamber accommodates fluid waste atomizers. The atomizers are arranged transversely of the chamber spaced apart from the axis of the burners by 0.4 to 0.7 of its internal diameter and are radially oriented.

A tap for letting out fused mineral components is provided in the lower portion of the gas duct. Fuel and air required for the combustion of both fuel and the organic components of the fluid waste are supplied to the upper portion of the cyclone furnace chamber.

The combustion of fuel terminates in the upper portion of the cyclone furnace chamber, after which the high-temperature combustion products with an excess of air oxygen are directed to the working chamber which is being supplied by the atomizers with fluid waste in a finely dispersed state. The drops of fluid waste evaporate in the working chamber, the organic components are decomposed and oxidized to form harmless gaseous products, and the dehydrated fusible



mineral components are pressed under the effect of centrifugal forces of the gas flow against the cooled walls of the working chamber and melted to form a liquid film flowing downwards and through the orifice in the bottom of the working chamber to the gas duct and further through the tap outside the furnace.

The orifice in the bottom of the working chamber acts as a turbulizer providing for intensive mixing of steam, gas and air in the cyclone furnace, thereby facilitating complete combustion of the organic components of the fluid waste.

The combustion products of the fuel and waste proceed from the gas duct either to a gas scrubbing system or a heat-utilizing equipment, and further to the atmosphere.

The basic advantages of cyclone furnaces are mainly due to their aerodynamic features (vortex pattern of the gas flow), which provides for high intensity of the process of fuel combustion with minimum fuel losses and rate of air consumption, as well as most favourable conditions of thermal and volumetric exchange between the gas medium and the drops of fluid waste as a result of high relative velocities and a high intensity of turbulence, making it possible to construct a small-size apparatus operating at high specific loads exceeding those of chamber and shaft furnaces tenfold.

The fuel combustion area in these cyclone furnaces is separated from the area of fluid waste evaporation and organic component oxidation by a row of atomizers arranged therebetween for spraying fluid waste beneath the row of burners, thereby contributing to a stable and intensive process of fuel combustion and eliminating the inhibiting effect of a number of fluid waste components on the fuel combustion process.

To intensify the combustion of gaseous fuel, use is made of burners allowing for preliminary or incomplete mixing, which ensure the smallest combustion area possible, and when liquid fuel is used for heating, the combined introduction of fuel and air ensures the required fineness of fuel dispersion. To spray fluid waste, use is made of highly economical mechanical centrifugal atomizers. The high reliability of incinerating fluid combustible wastes and industrial effluents in cyclone furnaces is due to the possibility of complete conversion of the toxic organic components at high temperatures to harmless gaseous products of complete combustion ($CO_2N_2$, $H_2O$).

This possibility is realized by providing for certain conditions and design parameters of the process, i.e. the temperature level in the working chamber, specific load of the volume, the level of turbulence, the dispersity of spraying fluid waste, etc.

During the combustion of various fuels in cyclone furnaces, high specific thermal stresses are developed and high specific weight loads of the working volume with respect to fluid waste are ensured. The small size of cyclone furnaces makes it possible to use water-cooled garnissage linings which ensure a continuous working cycle when incinerating fluid waste material containing organic and fusible mineral components. The provision of an efficient centrifugal separation system in cyclone furnaces makes it possible in this case to catch the greater amount of mineral substances which are subsequently let out of the furnace in the form of a melt, thereby considerably simplifying the system of scrubbing smoke gases from mineral vapours and dust prior to exhausting them into the atmosphere.

However, the prior art cyclone furnace has a disadvantage residing in that all of the air required for burning the fuel and the combustible components of the fluid waste is supplied to the burners arranged in its upper portion. With a high content of combustible components in the waste material or high heat values of their combustion, the coefficient of air consumption in burners reaches a value of 2 and over. The operation of pre-mixing gas burners is hampered by flame-outs. Besides, in the prior art cyclone furnaces, when the content of combustible components in the waste material is high, mixture formation becomes more difficult and since the sprayed fluid waste is not pre-mixed with the air required for burning up the combustible components, the conditions for complete combustion are impaired. In view of the above, the known furnaces make it impossible to incinerate fluid industrial waste material with a combustion heat exceeding 800 Kcal/l.

The known cyclone furnace is also disadvantageous in handling fluid waste material with a high content of fusible mineral components which deposit on the internal wall of the working chamber, thereby decreasing the coefficient of catching mineral salts in the cyclone furnace volume.

It is an object of the present invention to provide a cyclone furnace for reliable incineration of fluid industrial waste material with a high content of organic and mineral components, ensuring a high degree of catching the fused mineral components at minimum fuel and capital expenditures.

This object is accomplished by that a cyclone furnace for incinerating fluid industrial waste material containing organic or both organic and mineral components, comprising a vertical cylindrical chamber with burner means arranged in its upper portion tangentially to its walls to supply fuel and primary air to the chamber and with fluid waste atomizers arranged transversely of said chamber under the burner means, an orifice being provided in the bottom of the chamber to make the latter communicate with a gas duct for removing combustion products, and a tap provided in the lower portion of the gas duct for letting out fused mineral components is equipped, according to the invention, with nozzles for supplying secondary air, the nozzles being combined with the fluid waste atomizers.

The fluid waste atomizers can be arranged within the nozzles and directed counter the secondary air flow when fluid waste is incinerated containing only organic components the minimum content whereof corresponds to a combustion heat of 600–700 Kcal/l, and the maximum content corresponds to self-sustained burning.

When fluid waste is incinerated containing organic components, the minimum content thereof corresponding to a combustion heat of 600–700 Kcal/l and the maximum content corresponding to self-sustained burning, and fusible high-content mineral components, it is desirable that the fluid waste atomizer be arranged within the nozzles and directed counter the flow of secondary air.

In incinerating fluid waste containing organic components in an amount lower than that corresponding to a combustion heat of 600–700 Kcal/l, and fusible high-content mineral components, it is expedient that the fluid waste atomizers be arranged parallel to the axis of the nozzles and directed along the flow of secondary air.

It is possible, when incinerating fluid waste containing organic and low-content mineral components to arrange the fluid waste atomizers on the nozzle edges and to orient them radially.

Investigations have shown that the cyclone furnaces of the invention are capable of incinerating industrial waste with various classes of organic impurities, such as spirits, acids, ketones, aldehydes, fecals, amines, sulphur-, chlorine-, phosphorus- and sodium-organic compounds as well as salts, chlorides, carbonates, sulphates and other substances associated therewith.

In this case, the cyclone furnaces provide for reliable incineration of fluid industrial waste material with widely ranging concentrations of organic components, from microconcentrations to concentrations corresponding to a combustion heat of over 1,700 Kcal/l and smooth burning of combustible poor fuel-air mixtures, a high degree of catching mineral components within the operating volume of the furnace.

The inhibiting effect of the components in the waste on the process of combustion is eliminated in the cyclone furnaces of the present invention.

The testing of an experimental plant having a capacity of 0.25 $m^3/h$ for incinerating 25 percent aqueous solution of acetone with a combustion heat of 1,700 Kcal/l and a plant having a capacity of 4 $m^3/h$ for incinerating caprolactan production fluid waste containing organic, elementary organic and mineral components with a combustion heat of 1,700 Kcal/l, has demonstrated their reliability in operation.

The invention is further illustrated with reference to embodiments thereof, taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a diagrammatic cross-sectional view of a cyclone furnace, according to the invention;

FIG. **2** is a view taken along line II—II of FIG. **1**;

FIGS. **3, 4, 5, 6** are cross-sectional views of the cyclone furnace taken along the nozzles for supplying secondary air with a varying mutual arrangement of the fluid waste atomizers and nozzles for supplying secondary air, according to the invention.

The cyclone furnace for incinerating fluid industrial waste material containing organic or both organic and mineral components comprises a vertical cylindrical chamber **1** (FIG. **1**). Arranged in the upper portion of the chamber **1** tangentially to its walls are conventional burner means **2** (FIGS. **1, 2**) through which fuel and primary air required to burn the fuel are fed into the chamber **1**. Provided in a bottom **3** (FIG. **1**) of the chamber **1** is an orifice **4** making the chamber **1** communicate with the gas duct **5** for removing combustion products. A tap **6** located in the lower portion of the gas duct **5** is used to let out the fused bath of mineral salts.

Arranged transversely of the chamber **1** under the burner means **2** are fluid waste atomizers **7** combined with nozzles **8** for supplying secondary air required to burn the fluid waste. In this case, the mutual arrangement of the atomizers **7** and the nozzles **8** may vary depending on the composition of the fluid waste material to be incinerated.

FIG. **3** represents an arrangement of the atomizers **7** and the nozzles **8** when for incineration of fluid waste containing only organic components in a concentration whose lower limit corresponds to a combustion heat of 600–700 Kcal/l and the upper limit corresponds to self-sustained burning of the fluid waste. The atomizers **7**

are arranged within the nozzles **8** and are directed counter the flow of secondary air, thereby favouring finer dispersion of the fluid waste and better mixing of drops and vapours by the secondary air.

FIG. **4** illustrates an arrangement of the atomizers **7** within the nozzles **8** for incinerating fluid waste containing organic components in a concentration whose lower limit corresponds to a combustion heat of 600–700 Kcal/l, and the upper limit corresponds to self-sustained burning of the fluid waste, and fusible mineral components. The arrangement of the atomizers **7** within the nozzles **8** along the flow of secondary air ensures better mixing of drops and air and a highest degree of catching mineral components within the volume of the cyclone furnace.

FIG. **5** shows an arrangement of the atomizers **7** on the edges of the nozzles **8** and parallel to the axis thereof with an orientation along the flow of air. Such an arrangement of the atomizers is used for incinerating fluid waste containing organic components in a concentration which is lower than that corresponding to a combustion heat of 600–700 Kcal/l, and a high concentration of fusible mineral components. In this embodiment of the cyclone furnace the secondary air may not be supplied to the nozzles **8.** The above arrangement of the atomizers ensures a highest degree of catching fused mineral components.

FIG. **6** represents an arrangement of the atomizers **7** on the edges of the nozzles **8,** with the atomizers **7** being radially oriented. This embodiment is used for incinerating fluid waste containing only organic components in a concentration lower than that corresponding to a combustion heat of 600–700 Kcal/l. In this case, the secondary air may not be supplied to the nozzles. The above arrangement of the atomizers **7** ensures finer dispersion of drops by the gas flow and complete combustion of the organic components.

The number of burner means **2** (FIG. **1**) and nozzles **8** with the atomizers **7** is selected according to the predetermined capacity of the cyclone furnace.

The walls of the chamber **1** of the cyclone furnace have a lining.

In this case, for incinerating fluid waste with no or an insignificant amount of fusible mineral components and with organic components, or for incinerating fuel waste in which a small amount of mineral components is formed in the process of incineration, use is made of cyclone furnaces with a brick lining. Air jackets made of conventional steel are used to decrease the thickness of the lining.

For incinerating fluid waste containing fusible mineral components or when such components are formed in the process of incineration, use is made of cyclone furnaces with garnissage linings. Such linings necessitate through water or evaporation cooling.

To enhance the reliability of the burner means **2,** their nozzles are also water-cooled.

The cyclone furnace operates in the following manner.

Fuel and secondary air required for burning the fuel are supplied to the burner means **2.** The combustion of the fuel is over in that portion of the chamber **1** which houses the nozzles **8** for supplying secondary air and the fluid waste atomizers **7.** Dispersed fluid waste together with the secondary air introduced through the nozzles **8** is injected through the atomizers **7** into the high-temperature combustion products. Evaporation of the drops of fluid waste and oxidation of combustible mixtures by the oxygen of the secondary air take place when the flow of secondary air is mixed with the fuel combustion products. The combustion products passing through the orifice **4** are intimately mixed, which ensures complete burning of the combustible components. Fused particles of the mineral components are separated on the walls of the chamber **1** and introduced through the orifice **4** together with the combustion products into the gas duct **5** therefrom the melt is removed through the tap **6.**

What is claimed is:

**1.** A cyclone furnace for incinerating fluid industrial waste material containing organic or both organic and mineral components, comprising: a vertical cylindrical chamber; burner means arranged in the upper portion of said chamber tangentially to its walls for supplying fuel and air to said chamber; fluid waste atomizers arranged transversely of said chamber under said burner means; nozzles for supplying air, combined with said atomizers; a bottom of said chamber with an orifice provided therein; a gas duct for removing combustion products, communicating with said chamber through said orifice; a tap for letting out fused mineral components, provided in the lower portion of said gas duct.

**2.** A cyclone furnace as set forth in claim **1,** wherein said fluid waste atomizers are arranged within said nozzles for supplying air and are directed counter the airflow.

**3.** A cyclone furnace as set forth in claim **1,** wherein said fluid waste atomizers are arranged within said nozzles for supplying air and oriented in the direction of the airflow.

**4.** A cyclone furnace as set forth in claim **1,** wherein said fluid waste atomizers are arranged on the edges of said nozzles for supplying air, parallel to their axis and oriented in the direction of the airflow.

**5.** A cyclone furnace as set forth in claim **1,** wherein said fluid waste atomizers are arranged on the edges of said nozzles for supplying air and radially oriented.

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