

CPC**COOPERATIVE PATENT CLASSIFICATION****F23D****BURNERS** (generating combustion products of high pressure or high velocity [F23R](#))**F23D 1/00****Burners for combustion of pulverulent fuel** (disposition of burners [F23C](#))**F23D 1/005**

- . {burning a mixture of pulverulent fuel delivered as a slurry, i.e. comprising a carrying liquid (preparing slurries [F23K 1/02](#))}

F23D 1/02

- . Vortex burners, e.g. for cyclone-type combustion apparatus

F23D 1/04

- . Burners producing cylindrical flames without centrifugal action

F23D 1/06

- . Burners producing sheet flames

Combustion of a liquid**F23D 3/00****Burner using capillary action****F23D 3/02**

- . Wick burners

F23D 3/04

- .. with flame spreaders ([F23D 3/12](#) takes precedence)

F23D 3/06

- .. Inverted wick burners, e.g. for illumination

F23D 3/08

- .. characterised by shape, construction, or material, of wick

F23D 3/10

- .. Blue-flame burners

F23D 3/12

- ... with flame spreaders

F23D 3/14

- ... with mixing of air and fuel vapour in a chamber before the flame

F23D 3/16

- .. using candles ([candles per se C11C](#))

F23D 3/18

- .. Details of wick burners

F23D 3/20

- ... Flame spreaders

F23D 3/22

- ... Devices for mixing evaporated fuel with air

F23D 3/24

- ... Carriers for wicks

F23D 3/26

- Safety devices thereon

F23D 3/28

- ... Wick-adjusting devices

F23D 3/30

- directly engaging with the wick

F23D 3/32

- engaging with a tube carrying the wick

F23D 3/34

- Wick stop devices; Wick-fixing devices

F23D 3/36

- ... Devices for trimming wicks

F23D 3/38

- ... Devices for replacement of wicks

F23D 3/40

- . the capillary action taking place in one or more rigid porous bodies

F23D 5/00**Burners in which liquid fuel evaporates in the combustion space, with or without chemical conversion of evaporated fuel****F23D 5/02**

- . the liquid forming a pool, e.g. bowl-type evaporators, dish-type evaporators

F23D 5/04

- .. Pot-type evaporators, i.e. using a partially-enclosed combustion space

F23D 5/045

- ... {with forced draft}

F23D 5/06	<ul style="list-style-type: none"> the liquid forming a film on one or more plane or convex surfaces
F23D 5/08	<ul style="list-style-type: none"> on cascaded surfaces
F23D 5/10	<ul style="list-style-type: none"> on grids
F23D 5/12	<ul style="list-style-type: none"> Details
F23D 5/123	<ul style="list-style-type: none"> {Inserts promoting evaporation}
F23D 5/126	<ul style="list-style-type: none"> {Catalytic elements}
F23D 5/14	<ul style="list-style-type: none"> Maintaining predetermined amount of fuel in evaporator
F23D 5/16	<ul style="list-style-type: none"> Safety devices
F23D 5/18	<ul style="list-style-type: none"> Preheating devices
F23D 7/00	Burners in which drops of liquid fuel impinge on a surface
F23D 9/00	Burners in which a stream of liquid fuel impinges intermittently on a hot surface
F23D 11/00	Burners using a direct spraying action of liquid droplets or vaporised liquid into the combustion space (spraying in general B05B, B05D)
F23D 11/001	<ul style="list-style-type: none"> {spraying nozzle combined with forced draft fan in one unit (nozzles per se F23D 11/38)}
F23D 11/002	<ul style="list-style-type: none"> {spraying nozzle arranged within furnace openings (refractory bricks or blocks specially shaped for burner openings F23M 5/025)}
F23D 11/004	<ul style="list-style-type: none"> {for producing radiant heat}
F23D 11/005	<ul style="list-style-type: none"> {with combinations of different spraying or vaporising means}
F23D 11/007	<ul style="list-style-type: none"> {combination of means covered by sub-groups F23D 11/10 and F23D 11/24}
F23D 11/008	<ul style="list-style-type: none"> {combination of means covered by sub-groups F23D 5/00 and F23D 11/00}
F23D 11/02	<ul style="list-style-type: none"> the combustion space being a chamber substantially at atmospheric pressure
F23D 11/04	<ul style="list-style-type: none"> the spraying action being obtained by centrifugal action
F23D 11/06	<ul style="list-style-type: none"> using a horizontal shaft
F23D 11/08	<ul style="list-style-type: none"> using a vertical shaft
F23D 11/10	<ul style="list-style-type: none"> the spraying being induced by a gaseous medium, e.g. water vapour
F23D 11/101	<ul style="list-style-type: none"> {medium and fuel meeting before the burner outlet}
F23D 11/102	<ul style="list-style-type: none"> {in an internal mixing chamber}
F23D 11/103	<ul style="list-style-type: none"> {with means creating a swirl inside the mixing chamber}
F23D 11/104	<ul style="list-style-type: none"> {intersecting at a sharp angle, e.g. Y-jet atomiser}
F23D 11/105	<ul style="list-style-type: none"> {at least one of the fluids being submitted to a swirling motion}
F23D 11/106	<ul style="list-style-type: none"> {medium and fuel meeting at the burner outlet}
F23D 11/107	<ul style="list-style-type: none"> {at least one of both being subjected to a swirling motion}
F23D 11/108	<ul style="list-style-type: none"> {medium and fuel intersecting downstream of the burner outlet}
F23D 11/12	<ul style="list-style-type: none"> characterised by the shape or arrangement of the outlets from the nozzle
F23D 11/14	<ul style="list-style-type: none"> with a single outlet, e.g. slit
F23D 11/16	<ul style="list-style-type: none"> in which an emulsion of water and fuel is sprayed
F23D 11/18	<ul style="list-style-type: none"> the gaseous medium being water vapour generated at the nozzle

- F23D 11/20 . . . the water vapour being superheated
 - F23D 11/22 . . the gaseous medium being vaporised fuel, e.g. for a soldering lamp, {or other gaseous fuel}
 - F23D 11/24 . by pressurisation of the fuel before a nozzle through which it is sprayed by a substantial pressure reduction into a space
 - F23D 11/26 . . with provision for varying the rate at which the fuel is sprayed
 - F23D 11/28 . . . with flow-back of fuel at the burner, e.g. using by-pass
 - F23D 11/30 . . . with return feed of uncombusted sprayed fuel to reservoir
 - F23D 11/32 . by electrostatic means
 - F23D 11/34 . by ultrasonic means {or other kinds of vibrations}
 - F23D 11/345 . . {with vibrating atomiser surfaces}
 - F23D 11/36 . Details {e.g. burner cooling means, noise reduction means}
 - F23D 11/38 . . Nozzles (nozzles in general [B05B](#)); Cleaning devices therefor
 - F23D 11/383 . . . {with swirl means}
 - F23D 11/386 . . . {Nozzle cleaning}
 - F23D 11/40 . . Mixing tubes [or chambers]; Burner heads
 - F23D 11/402 . . . {Mixing chambers downstream of the nozzle}
 - F23D 11/404 . . . {Flame tubes (not forming part of the burner [F23M 9/06](#))}
 - F23D 11/406 . . . {Flame stabilising means, e.g. flame holders}
 - F23D 11/408 . . . {Flow influencing devices in the air tube}
 - F23D 11/42 . . Starting devices (igniting [F23Q](#))
 - F23D 11/44 . . Preheating devices; Vaporising devices (vaporising devices per se [F23K 5/22](#))
 - F23D 11/441 . . . {Vaporizing devices incorporated with burners}
 - F23D 11/443 {heated by the main burner flame}
 - F23D 11/445 {the flame and the vaporiser not coming into direct contact}
 - F23D 11/446 {heated by an auxiliary flame}
 - F23D 11/448 {heated by electrical means}
 - F23D 11/46 . . Devices on the vaporiser for controlling the feeding of the fuel
- F23D 14/00 Burners for combustion of a gas, e.g. of a gas stored under pressure as a liquid**
- F23D 14/02 . Premix gas burners, i.e. in which gaseous fuel is mixed with combustion air upstream of the combustion zone
 - F23D 14/04 . . induction type, e.g. Bunsen burner, ({atmospheric or aerated gas burner})
 - F23D 14/045 . . . {with a plurality of burner bars assembled together, e.g. in a grid-like arrangement}
 - F23D 14/06 . . . with radial outlets at the burner head
 - F23D 14/065 {with injector axis inclined to the burner head axis}
 - F23D 14/08 . . . with axial outlets at the burner head
 - F23D 14/085 {with injector axis inclined to the burner head axis}
 - F23D 14/10 . . . with elongated tubular burner head
 - F23D 14/105 [N. with injector axis parallel to the burner head axis]

- F23D 14/12 . Radiant burners
- F23D 14/125 . . {heating a wall surface to incandescence}
- F23D 14/14 . . using screens or perforated plates
- F23D 14/145 . . . {the burner plate being a screen}
- F23D 14/16 . . using permeable blocks
- F23D 14/18 . . using catalysis for flameless combustion
- F23D 14/20 . Non-premix gas burners, i.e. in which gaseous fuel is mixed with combustion air on arrival at the combustion zone ([F23D 14/30 to F23D 14/44 take precedence](#))
- F23D 14/22 . . with separate air and gas feed ducts, e.g. with ducts running parallel or crossing each other
- F23D 14/24 . . . at least one of the fluids being submitted to a swirling motion
- F23D 14/26 . with provision for a retention flame ([pilot flame igniters F23Q 9/00](#))
- F23D 14/28 . in association with a gaseous fuel source, e.g. acetylene generator, or a container for liquefied gas
- F23D 14/30 . Inverted burners, e.g. for illumination
- F23D 14/32 . using a mixture of gaseous fuel and pure oxygen or oxygen-enriched air ([F23D 14/38 takes precedence](#))
- F23D 14/34 . Burners specially adapted for use with means for pressurising the gaseous fuel or the combustion air ([F23D 14/38 takes precedence](#))
- F23D 14/36 . . in which the compressor and burner form a single unit
- F23D 14/38 . Torches, e.g. for cutting, brazing, welding or heating ({ [nozzles for torches F23D 14/52](#)})
- F23D 14/40 . . for welding ([F23D 14/44 takes precedence](#))
- F23D 14/42 . . for cutting ([F23D 14/44 takes precedence](#))
- F23D 14/44 . . for use under water
- F23D 14/46 . Details {e.g. [noise reduction means](#)}
- F23D 14/465 . . {for torches ([F23D 14/52 takes precedence](#))}
- F23D 14/48 . . Nozzles ({[injectors for mixing devices F23D 14/64](#)}; for spraying or coating [B05B](#))
- F23D 14/50 . . . Cleaning devices therefor
- F23D 14/52 . . . for torches; for blow-pipes
- F23D 14/54 for cutting or welding metal
- F23D 14/56 . . . for spreading the flame over an area, e.g. for desurfacing of solid material, for surface hardening, for heating workpieces, ([scarfing by applying flames B23K 7/00](#))
- F23D 14/58 . . . characterised by the shape or arrangement of the outlet or outlets from the nozzle, e.g. of annular configuration
- F23D 14/583 {of elongated shape, e.g. slits}
- F23D 14/586 {formed by a set of sheets, strips, ribbons or the like}
- F23D 14/60 . . Devices for simultaneous control of gas and combustion air ([regulation of combustion in general F23N](#))
- F23D 14/62 . . Mixing devices; Mixing tubes
- F23D 14/64 . . . with injectors
- F23D 14/66 . . Preheating the combustion air or gas

- F23D 14/68 . . Treating the combustion air or gas, e.g. by filtering, by moistening (in general B01)
- F23D 14/70 . . Baffles or like flow-disturbing devices
- F23D 14/72 . . Safety devices, e.g. operative in case of failure of gas supply (protection or supervision of pipe-line systems F17D 5/00)
- F23D 14/725 . . . {Protection against flame failure by using flame detection devices (pilot flame igniters with interlock with main fuel supply F23Q 9/08)}
- F23D 14/74 . . . Preventing flame lift-off (F23D 14/70 takes precedence)
- F23D 14/76 . . . Protecting flame and burner parts
- F23D 14/78 . . . Cooling burner parts
- F23D 14/80 . . . Selection of a non-toxic gas
- F23D 14/82 . . . Preventing flashback or blowback (F23D 14/70 takes precedence; {by use of a retention flame F23D 14/26}; in gas feed lines A62C 4/02)
- F23D 14/825 {using valves}
- F23D 14/84 . . Flame spreading or otherwise shaping (F23D 14/70 takes precedence)

Other burners

F23D 17/00 Burners for combustion conjointly or alternatively of gaseous or liquid or pulverulent fuel

- F23D 17/002 . {gaseous or liquid fuel}
- F23D 17/005 . {gaseous or pulverulent fuel}
- F23D 17/007 . {liquid or pulverulent fuel}

F23D 21/00 Burners not otherwise provided for

NOTE

{ combinations of spraying or vaporising means covered by sub-groups F23D 5/00 and F23D 21/00 are classified in F23D 11/008 }

- F23D 21/005 . {specially adapted for use in particular heating operations}

F23D 23/00 Assemblies of two or more burners (gas burners with provision for a retention flame F23D 14/26; disposition of burners F23C; for industrial furnaces F27)

F23D 99/00 Subject matter not provided for in other groups of this subclass

- F23D 99/003 . {specially adapted for use in particular heating operations}
- F23D 99/006 . . {for heating liquids, e.g. for vaporising, for concentrating}

F23D 2200/00 Burners for fluid fuel

F23D 2201/00 Burners adapted for particulate solid or pulverulent fuels

- F23D 2201/10 . Nozzle tips
- F23D 2201/101 . . tiltable
- F23D 2201/20 . Fuel flow guiding devices

F23D 2201/30 . Wear protection

F23D 2202/00 Liquid fuel burners

F23D 2203/00 Gaseous fuel burners

- F23D 2203/002 . Radiant burner mixing tubes
- F23D 2203/005 . Radiant burner heads
- F23D 2203/007 . Mixing tubes, air supply regulation
- F23D 2203/10 . Flame diffusing means
 - F23D 2203/101 . . characterised by surface shape
 - F23D 2203/1012 . . . tubular
 - F23D 2203/1015 . . . spherical
 - F23D 2203/1017 . . . curved
 - F23D 2203/102 . . using perforated plates
 - F23D 2203/1023 . . . with specific free passage areas
 - F23D 2203/1026 . . . with slotshaped openings
 - F23D 2203/103 . . using screens
 - F23D 2203/104 . . Grids, e.g. honeycomb grids
 - F23D 2203/105 . . Porous plates
 - F23D 2203/1055 . . . with a specific void range
 - F23D 2203/106 . . Assemblies of different layers
 - F23D 2203/107 . . coated with catalysts
 - F23D 2203/108 . . with stacked sheets or strips forming the outlets

F23D 2204/00 Burners adapted for simultaneous or alternative combustion having more than one fuel supply

- F23D 2204/10 . gaseous and liquid fuel
- F23D 2204/20 . gaseous and pulverulent fuel
- F23D 2204/30 . liquid and pulverulent fuel

F23D 2205/00 Assemblies of two or more burners, irrespective of fuel type

F23D 2206/00 Burners for specific applications

- F23D 2206/0005 . Liquid fuel burners adapted for use in locomotives
- F23D 2206/001 . Liquid fuel burners adapted for use in automobile steam boilers
- F23D 2206/0015 . Gas burners for use in retort furnaces
- F23D 2206/0021 . Gas burners for use in furnaces of the reverberatory, muffle or crucible type
- F23D 2206/0026 . Vapour burners adapted for use in illumination devices
- F23D 2206/0031 . Liquid fuel burners adapted for use in welding lamps
- F23D 2206/0036 . . Liquid fuel burners adapted for use in welding and cutting metals
- F23D 2206/0042 . Vapour burners for illumination by radiation, with vaporiser heated by an auxiliary flame

F23D 2206/0047	. Vapour burners for illumination by radiation, with vaporiser heated by the main flame
F23D 2206/0052	. Vapour burners for illumination by radiation, with vaporiser heated by conduction
F23D 2206/0057	. Liquid fuel burners adapted for use in illumination and heating
F23D 2206/0063	.. Catalytic burners adapted for use in illumination and heating
F23D 2206/0068	. Gas burners for illumination with slot type nozzles
F23D 2206/0073	. Gas burners for illumination with Argand nozzles
F23D 2206/0078	. Gas burners adapted for use in lamps with preheated air
F23D 2206/0084	. Gas burners adapted for use in ceiling and wagon lamps
F23D 2206/0089	. Gas burners for illumination using acetylene as a fuel
F23D 2206/0094	. Gas burners adapted for use in illumination and heating
F23D 2206/10	. Turbines
F23D 2207/00	Ignition devices associated with burner
F23D 2208/00	Control devices associated with burners
F23D 2208/005	. Controlling air supply in radiant gas burners
F23D 2208/10	. Sensing devices
F23D 2209/00	Safety arrangements
F23D 2209/10	. Flame flashback
F23D 2209/20	. Flame lift-off / stability
F23D 2209/30	. Purging
F23D 2210/00	Noise abatement
F23D 2210/101	. using noise dampening material
F23D 2211/00	Thermal dilatation prevention or compensation
F23D 2212/00	Burner material specifications
F23D 2212/005	. Radiant gas burners made of specific materials, e.g. rare earths
F23D 2212/10	. ceramic
F23D 2212/101	.. Foam, e.g. reticulated
F23D 2212/103	.. Fibres
F23D 2212/105	.. Particles
F23D 2212/20	. metallic
F23D 2212/201	.. Fibres
F23D 2212/203	.. Particles
F23D 2213/00	Burner manufacture specifications
F23D 2214/00	Cooling
F23D 2700/00	TBD
F23D 2700/001	. Air supply for wick burners

F23D 2700/002	. Wick burners without flame spreaders or burner hood
F23D 2700/003	. Wick burners with flame spreaders or burner hood
F23D 2700/004	. Inverted wick burners, wick burners using preheated air
F23D 2700/005	. Wick burners using alcohol as a fuel
F23D 2700/006	. Wick burners using oil as a fuel
F23D 2700/009	. Details of blue flame wick burners
F23D 2700/01	. Blue flame burners without flame spreader or burner hood
F23D 2700/011	. Blue flame burners with flame spreader or burner hood without a bead at the wick carrying tube
F23D 2700/012	. Blue flame burners with flame spreader or burner hood with a bead at the wick carrying tube
F23D 2700/013	. Blue flame burners with flame on one side only without a bead at the wick carrying tube
F23D 2700/014	. Blue flame burners with flame on one side only and a bead at the wick carrying tube
F23D 2700/015	. Tubes carrying the wick
F23D 2700/016	. Safety devices for wick carrying tubes
F23D 2700/017	. Wick adjusting devices directly engaging the wick
F23D 2700/018	. Wick adjusting devices engaging the tube carrying the wick
F23D 2700/019	. Wick stop devices and wick fixing devices
F23D 2700/02	. Devices for mounting the wick to the carrier
F23D 2700/021	. Burners in which the gas produced in the wick is not burned instantaneously
F23D 2700/022	. Burners using carburetted gas
F23D 2700/023	. Gasifying and evaporating devices
F23D 2700/024	. Nozzles and cleaning devices therefor
F23D 2700/025	. Mixing tubes and burner heads
F23D 2700/026	. Preheating devices, starting devices
F23D 2700/027	. Vaporisers with devices for controlling the feeding of the fuel
F23D 2700/03	. Alcohol vapour burners
F23D 2700/031	. Vapour burners where the vaporiser is heated by an auxiliary flame
F23D 2700/032	. Vapour burners where the vaporiser is heated by the main flame itself
F23D 2700/033	. Vapour burners where the vaporiser is heated by conduction
F23D 2900/00	Special features of, or arrangements for burners using fluid fuels or solid fuels suspended in a carrier gas
F23D 2900/00001	. local catalytic coatings applied to burner surfaces
F23D 2900/00002	. Cleaning burner parts, e.g. burner tips
F23D 2900/00003	. Fuel or fuel-air mixtures flow distribution devices upstream of the outlet
F23D 2900/00004	. Burners specially adapted for generating high luminous flames, e.g. yellow for fuel-rich mixtures
F23D 2900/00006	. Liquid fuel burners using pure oxygen or O ₂ -enriched air as oxidant (for gaseous fuels F23D 14/32)
F23D 2900/00008	. Burner assemblies with diffusion and premix modes, i.e. dual mode burners

- F23D 2900/00011 . Burner with means for propagating the flames along a wall surface
- F23D 2900/00012 . Liquid or gas fuel burners with flames spread over a flat surface, either premix or non-premix type, e.g. "Flächenbrenner"
- F23D 2900/00013 . . with means for spreading the flame in a fan or fishtail shape over a melting bath
- F23D 2900/00014 . Pilot burners specially adapted for ignition of main burners in furnaces or gas turbines
- F23D 2900/00015 . Pilot burners specially adapted for low load or transient conditions, e.g. for increasing stability
- F23D 2900/00016 . Preventing or reducing deposit build-up on burner parts, e.g. from carbon
- F23D 2900/00017 . Assembled burner modules
- F23D 2900/00018 . Means for protecting parts of the burner, e.g. ceramic lining outside of the flame tube
- F23D 2900/00019 . Outlet manufactured from knitted fibres
- F23D 2900/01001 . Pulverised solid fuel burner with means for swirling the fuel-air mixture
- F23D 2900/03081 . Catalytic wick burners
- F23D 2900/03082 . Wick made of specific material, e.g. ceramic
- F23D 2900/05001 . Burner using gel type fuel
- F23D 2900/05002 . Use of porous members to convert liquid fuel into vapor
- F23D 2900/11001 . Impinging-jet injectors or jet impinging on a surface
- F23D 2900/11002 . Liquid fuel burners with more than one nozzle
- F23D 2900/11101 . Pulverising gas flow impinging on fuel from pre-filming surface, e.g. lip atomizers
- F23D 2900/11401 . Flame intercepting baffles forming part of burner head
- F23D 2900/11402 . Airflow diaphragms at burner nozzle
- F23D 2900/11403 . Flame surrounding tubes in front of burner nozzle
- F23D 2900/14 . Special features of gas burners
- F23D 2900/14001 . . Sealing or support of burner plate borders
- F23D 2900/14002 . . of premix or non premix types, specially adapted for the combustion of low heating value (LHV) gas
- F23D 2900/14003 . . with more than one nozzle
- F23D 2900/14004 . . with radially extending gas distribution spokes
- F23D 2900/14005 . . Rotary gas burner
- F23D 2900/14021 . . Premixing burners with swirling or vortices creating means for fuel or air
- F23D 2900/14041 . . Segmented or straight line assembly of burner bars
- F23D 2900/14042 . . Star shaped assembly of burner bars or arms
- F23D 2900/14061 . . for cooking ranges having a coated burner cap
- F23D 2900/14062 . . for cooking ranges having multiple flame rings
- F23D 2900/14063 . . for cooking ranges having one flame ring fed by multiple venturis
- F23D 2900/14064 . . Burner heads of non circular shape
- F23D 2900/1412 . . for radiant burners
- F23D 2900/14121 . . . with radiation intensifying means
- F23D 2900/14122 . . . with extra radiation grids, e.g. strips or rods
- F23D 2900/14123 . . . with radiation intensifying perforated plates
- F23D 2900/14124 . . . cooperating with refractory wall surfaces

- F23D 2900/14125 . . . with extra radiation screens, e.g. wires, threads or gauzes
- F23D 2900/14181 . . . Catalytic type with carbon containing radiating surface
- F23D 2900/14241 . . Post-mixing with swirling means
- F23D 2900/14381 . . Single operating member opening and closing fuel and oxidant supply valves in torches
- F23D 2900/14481 . . Burner nozzles incorporating flow adjusting means
- F23D 2900/14482 . . Burner nozzles incorporating a fluidic oscillator
- F23D 2900/14581 . . with outlets consisting of a bed of irregular particles, e.g. glass
- F23D 2900/14582 . . with outlets consisting of layers of spherical particles
- F23D 2900/14641 . . with gas distribution manifolds or bars provided with a plurality of nozzles
- F23D 2900/14642 . . with jet mixers with more than one gas injection nozzles or orifices for a single mixing tube
- F23D 2900/14681 . . Adding steam or water vapor to primary or secondary combustion air
- F23D 2900/14701 . . Swirling means inside the mixing tube or chamber to improve premixing
- F23D 2900/21 . Burners specially adapted for a particular use
 - F23D 2900/21001 . . for use in blast furnaces
 - F23D 2900/21002 . . for use in car heating systems
 - F23D 2900/21003 . . for heating or re-burning air or gas in a duct
 - F23D 2900/21004 . . for use in gas fed fireplaces
 - F23D 2900/21005 . . for flame deposition, e.g. FHD, flame hydrolysis deposition
 - F23D 2900/21006 . . for heating a catalyst in a car
 - F23D 2900/21007 . . for producing soot, e.g. nano particle soot