# SECTION F — MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; BLASTING

## F28 HEAT EXCHANGE IN GENERAL

**Note(s)**

1. In this class, the following expressions are used with the meanings indicated:
   - "heat exchange" means the heating or cooling of a fluid or fluent solid by direct or indirect contact with a heated or cooled fluid or fluent solid;
   - "heat transfer" means the heating or cooling of a fluid or fluent solid by direct contact with a heated or cooled surface or body.
2. Apparatus using heat exchange or heat transfer (as defined in Note (1) above) for specific purposes is classified either in subclass F28B or in the appropriate subclasses of, for example, classes F22, F24, F25, F26, or F27; if no such other subclass is appropriate, such apparatus is classified in subclass F28C or F28D.

**F28B** **STEAM OR VAPOUR CONDENSERS** (condensation of vapours B01D 5/00; condensation during pretreatment of gases prior to electrostatic precipitation of dispersed particles B03C 3/014; steam engine plants having condensers F01K; liquefaction of gases F25J; details of heat-exchange or heat-transfer arrangements of general application F28F)

**1/00** **Condensers in which the steam or vapour is separated from the cooling medium by walls, e.g. surface condenser [1, 2006.01]**

1/02 • using water or other liquid as the cooling medium **[1, 2006.01]**

1/04 • • employing moving walls **[1, 2006.01]**

1/06 • using air or other gas as the cooling medium **[1, 2006.01]**

1/08 • • employing moving walls **[3, 2006.01]**

**3/00** **Condensers in which the steam or vapour comes into direct contact with the cooling medium [1, 2006.01]**

3/02 • by providing a flowing coating of cooling liquid on the condensing surface **[1, 2006.01]**

3/04 • by injecting cooling liquid into the steam or vapour (F28B 3/08 takes precedence) **[1, 2006.01]**

3/06 • by injecting the steam or vapour into the cooling liquid (F28B 3/08 takes precedence) **[1, 2006.01]**

3/08 • with rotatable members **[1, 2006.01]**

**5/00** **Condensers employing a combination of the methods covered by groups F28B 1/00 and F28B 3/00; Other condensers [1, 2006.01]**

**7/00** **Combinations of two or more condensers, e.g. provision of reserve condenser [1, 2006.01]**

**9/00** **Auxiliary systems, arrangements, or devices [1, 2006.01]**

9/02 • for feeding steam or vapour to condensers **[1, 2006.01]**

9/04 • for feeding, collecting, and storing cooling water or other cooling liquid **[1, 2006.01]**

9/06 • • with provision for re-cooling the cooling water or other cooling liquid **[1, 2006.01]**

9/08 • for collecting and removing condensate **[1, 2006.01]**

9/10 • for extracting, cooling, and removing non-condensable gases **[1, 2006.01]**

**11/00** **Controlling arrangements with features specially adapted for condensers [1, 2006.01]**

**F28C** **HEAT-EXCHANGE APPARATUS, NOT PROVIDED FOR IN ANOTHER SUBCLASS, IN WHICH THE HEAT-EXCHANGE MEDIA COME INTO DIRECT CONTACT WITHOUT CHEMICAL INTERACTION** (heat-transfer, heat-exchange or heat-storage materials C09K 5/00; fluid heaters having heat generating means F24H; with an intermediate heat-transfer medium coming into direct contact with heat-exchange media F28D 15/00-F28D 19/00; details of heat-exchange apparatus of general application F28F)

**1/00** **Direct-contact trickle coolers, e.g. cooling towers** (building construction E04H 5/12; enclosed spaces cooled by trickle F25; component parts of trickle coolers F28F 25/00) **[1, 2006.01]**

1/02 • with counter-current only **[1, 2006.01]**

1/04 • with cross-current only **[1, 2006.01]**

1/06 • with both counter-current and cross-current **[1, 2006.01]**

1/08 • Arrangements for recovering heat from exhaust steam **[1, 2006.01]**

1/10 • Arrangements for suppressing noise **[1, 5, 2006.01]**

1/12 • Arrangements for preventing clogging by frost **[3, 2006.01]**

1/14 • comprising also a non-direct contact heat exchange **[3, 2006.01]**

1/16 • Arrangements for preventing condensation, precipitation or mist formation, outside the cooler (F28C 1/14 takes precedence) **[3, 2006.01]**

**3/00** **Other direct-contact heat-exchange apparatus [1, 2006.01]**

3/02 • the heat-exchange media both being gases or vapours **[1, 2006.01]**

3/04 • the heat-exchange media both being liquids **[1, 2006.01]**

3/06 • the heat-exchange media being a liquid and a gas or vapour (temperators for cooling steam F22) **[1, 2006.01]**

3/08 • • with change of state, e.g. absorption, evaporation, condensation (generating steam under pressure F22) **[1, 2006.01]**

3/10 • one heat-exchange medium at least being a fluent solid, e.g. a particulate material **[1, 2006.01]**

3/12 • • the heat-exchange medium being a particulate material and a gas, vapour, or liquid **[1, 2006.01]**

3/14 • • • the particulate material moving by gravity, e.g. down a tube **[1, 2006.01]**

3/16 • • • the particulate material forming a bed, e.g. fluidised, on vibratory sieves **[1, 2006.01]**

3/18 • • • the particulate material being contained in rotating drums **[1, 2006.01]**

**F28D HEAT-EXCHANGE APPARATUS, NOT PROVIDED FOR IN ANOTHER SUBCLASS, IN WHICH THE HEAT-EXCHANGE MEDIA DO NOT COME INTO DIRECT CONTACT** (heat-transfer, heat-exchange or heat-storage materials C09K 5/00; fluid heaters having heat generating means and heat transferring means F24H; furnaces F27; details of heat-exchange apparatus of general application F28F)**; HEAT STORAGE PLANTS OR APPARATUS IN GENERAL [4]**

**Subclass index**



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**1/00 Heat-exchange apparatus having stationary conduit assemblies for one heat-exchange medium only, the media being in contact with different sides of the conduit wall, in which the other heat-exchange medium is a large body of fluid, e.g. domestic or motor car radiators** (F28D 5/00 takes precedence) **[1, 2006.01]**

1/02 • with the heat-exchange conduits immersed in the body of fluid **[1, 2006.01]**

1/03 • • with plate-like or laminated conduits **[4, 2006.01]**

1/04 • • with tubular conduits **[1, 2006.01]**

1/047 • • • the conduits being bent, e.g. in a serpentine or zig-zag **[4, 2006.01]**

1/053 • • • the conduits being straight **[4, 2006.01]**

1/06 • with the heat-exchange conduits forming part of, or being attached to, the tank containing the body of fluid **[1, 2006.01]**

**3/00 Heat-exchange apparatus having stationary conduit assemblies for one heat-exchange medium only, the media being in contact with different sides of the conduit wall, in which the other heat-exchange medium flows in a continuous film, or trickles freely, over the conduits** (F28D 5/00 takes precedence) **[1, 2006.01]**

3/02 • with tubular conduits **[1, 2006.01]**

3/04 • Distributing arrangements **[1, 2006.01]**

**5/00 Heat-exchange apparatus having stationary conduit assemblies for one heat-exchange medium only, the media being in contact with different sides of the conduit wall, using the cooling effect of natural or forced evaporation [1, 2006.01]**

5/02 • in which the evaporating medium flows in a continuous film or trickles freely over the conduits **[1, 2006.01]**

**7/00 Heat-exchange apparatus having stationary tubular conduit assemblies for both heat-exchange media, the media being in contact with different sides of a conduit wall [1, 2006.01]**

7/02 • the conduits being helically coiled (F28D 7/10 takes precedence) **[1, 2006.01]**

7/04 • the conduits being spirally coiled (F28D 7/10 takes precedence) **[1, 2006.01]**

7/06 • the conduits having a single U-bend (F28D 7/10 takes precedence) **[1, 2006.01]**

7/08 • the conduits being otherwise bent, e.g. in a serpentine or zig-zag (F28D 7/10 takes precedence) **[1, 2006.01]**

7/10 • the conduits being arranged one within the other, e.g. concentrically **[1, 2006.01]**

7/12 • • the surrounding tube being closed at one end, i.e. return type (F28D 7/14 takes precedence) **[1, 2006.01]**

7/14 • • both tubes being bent **[1, 2006.01]**

7/16 • the conduits being arranged in parallel spaced relation (F28D 7/02-F28D 7/10 take precedence) **[4, 2006.01]**

**9/00 Heat-exchange apparatus having stationary plate-like or laminated conduit assemblies for both heat-exchange media, the media being in contact with different sides of a conduit wall [1, 2006.01]**

9/02 • the heat-exchange media travelling at an angle to one another (F28D 9/04 takes precedence) **[1, 2006.01]**

9/04 • the conduits being formed by spirally-wound plates or laminae **[1, 2006.01]**

**11/00 Heat-exchange apparatus employing moving conduits [1, 2006.01]**

11/02 • the movement being rotary, e.g. performed by a drum or roller (F28D 11/08 takes precedence) **[1, 2006.01]**

11/04 • • performed by a tube or a bundle of tubes **[1, 2006.01]**

11/06 • the movement being reciprocating or oscillating (F28D 11/08 takes precedence) **[1, 2006.01]**

11/08 • more than one conduit assembly performing independent movements, e.g. rotary bundle of tubes in a rotary drum **[1, 2006.01]**

**13/00 Heat-exchange apparatus using a fluidised bed [1, 2006.01]**

**Heat-exchange apparatus employing intermediate heat-transfer media or bodies [3]**

**15/00 Heat-exchange apparatus with the intermediate heat-transfer medium in closed tubes passing into or through the conduit walls [1, 2006.01]**

15/02 • in which the medium condenses and evaporates, e.g. heat-pipes **[4, 2006.01]**

15/04 • • with tubes having a capillary structure **[6, 2006.01]**

15/06 • • Control arrangements therefor **[6, 2006.01]**

**17/00 Regenerative heat-exchange apparatus in which a stationary intermediate heat-transfer medium or body is contacted successively by each heat-exchange medium, e.g. using granular particles [1, 2006.01]**

17/02 • using rigid bodies, e.g. of porous material **[1, 2006.01]**

17/04 • Distributing arrangements for the heat-exchange media **[1, 2006.01]**

**19/00 Regenerative heat-exchange apparatus in which the intermediate heat-transfer medium or body is moved successively into contact with each heat-exchange medium [1, 2006.01]**

19/02 • using granular particles **[1, 2006.01]**

19/04 • using rigid bodies, e.g. mounted on a movable carrier **[1, 2006.01]**

**20/00 Heat storage plants or apparatus in general; Regenerative heat-exchange apparatus not covered by groups F28D 17/00 or F28D 19/00 [4, 2006.01]**

20/02 • using latent heat **[6, 2006.01]**

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**21/00 Heat-exchange apparatus not covered by any of the groups F28D 1/00-F28D 20/00 [1, 4, 2006.01]**

**F28F DETAILS OF HEAT-EXCHANGE OR HEAT-TRANSFER APPARATUS, OF GENERAL APPLICATION** (heat-transfer, heat-exchange or heat-storage materials C09K 5/00; water or air traps, air venting F16)

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**1/00 Tubular elements; Assemblies of tubular elements** (specially adapted for movement F28F 5/00) **[1, 2006.01]**

1/02 • Tubular elements of cross-section which is non-circular (F28F 1/08, F28F 1/10 take precedence) **[1, 2006.01]**

1/04 • • polygonal, e.g. rectangular **[1, 2006.01]**

1/06 • • crimped or corrugated in cross-section **[1, 2006.01]**

1/08 • Tubular elements crimped or corrugated in longitudinal section **[1, 2006.01]**

1/10 • Tubular elements or assemblies thereof with means for increasing heat-transfer area, e.g. with fins, with projections, with recesses (crimped or corrugated elements F28F 1/06, F28F 1/08) **[1, 2006.01]**

1/12 • • the means being only outside the tubular element **[1, 2006.01]**

1/14 • • • and extending longitudinally (F28F 1/38 takes precedence) **[1, 2006.01]**

1/16 • • • • the means being integral with the element, e.g. formed by extrusion (F28F 1/22 takes precedence) **[1, 2006.01]**

1/18 • • • • • the element being built-up from finned sections **[1, 2006.01]**

1/20 • • • • the means being attachable to the element (F28F 1/22 takes precedence) **[1, 2006.01]**

1/22 • • • • the means having portions engaging further tubular elements **[1, 2006.01]**

1/24 • • • and extending transversely (F28F 1/38 takes precedence) **[1, 2006.01]**

1/26 • • • • the means being integral with the element (F28F 1/32 takes precedence) **[1, 2006.01]**

1/28 • • • • • the element being built-up from finned sections **[1, 2006.01]**

1/30 • • • • the means being attachable to the element (F28F 1/32 takes precedence) **[1, 2006.01]**

1/32 • • • • the means having portions engaging further tubular elements **[1, 2006.01]**

1/34 • • • and extending obliquely (F28F 1/38 takes precedence) **[1, 2006.01]**
1/36 • • • • the means being helically-wound fins or wire spirals **[1, 2006.01]**
1/38 • • • and being staggered to form tortuous fluid passages **[1, 2006.01]**
1/40 • • the means being only inside the tubular element **[1, 2006.01]**
1/42 • • the means being both outside and inside the tubular element **[1, 2006.01]**
1/44 • • • and being formed of wire mesh **[1, 2006.01]**

**3/00 Plate-like or laminated elements; Assemblies of plate-like or laminated elements** (specially adapted for movement F28F 5/00) **[1, 2006.01]**
3/02 • Elements or assemblies thereof with means for increasing heat-transfer area, e.g. with fins, with recesses, with corrugations (F28F 3/08 takes precedence) **[1, 2006.01]**
3/04 • • the means being integral with the element **[1, 2006.01]**
3/06 • • the means being attachable to the element **[1, 2006.01]**
3/08 • Elements constructed for building-up into stacks, e.g. capable of being taken apart for cleaning **[1, 2006.01]**
3/10 • • Arrangement for sealing the margins **[1, 2006.01]**
3/12 • Elements constructed in the shape of a hollow panel, e.g. with channels **[1, 2006.01]**
3/14 • • by separating portions of a pair of joined sheets to form channels, e.g. by inflation (manufacture thereof B23P) **[1, 2006.01]**

**5/00 Elements specially adapted for movement** (arrangements for moving the elements, see the appropriate subclass for the apparatus concerned) **[1, 2006.01]**
5/02 • Rotary drums or rollers **[1, 2006.01]**
5/04 • Hollow impellers, e.g. stirring vane **[1, 2006.01]**
5/06 • Hollow screw conveyors **[1, 2006.01]**

**7/00 Elements not covered by group F28F 1/00, F28F 3/00, or F28F 5/00 [1, 2006.01]**
7/02 • Blocks traversed by passages for heat-exchange media **[1, 2006.01]**

**9/00 Casings; Header boxes; Auxiliary supports for elements; Auxiliary members within casings [1, 2006.01]**
9/007 • Auxiliary supports for elements **[6, 2006.01]**
9/013 • • for tubes or tube-assemblies **[6, 2006.01]**
9/02 • Header boxes; End plates **[1, 2006.01]**
9/04 • • Arrangements for sealing elements into header boxes or end plates (joining pipes to walls in general F16L 41/00) **[1, 2006.01]**
9/06 • • • by dismountable joints **[1, 2006.01]**
9/08 • • • • by wedge-type connections, e.g. taper ferrule **[1, 2006.01]**
9/10 • • • • by screw-type connections, e.g. gland **[1, 2006.01]**
9/12 • • • • by flange-type connections **[1, 2006.01]**
9/14 • • • • by force-joining **[1, 2006.01]**
9/16 • • • by permanent joints, e.g. by rolling (metal-working procedures in general B21, B23, particularly B21D 39/06, B23K) **[1, 2006.01]**
9/18 • • • • by welding **[1, 2006.01]**
9/20 • Arrangements of heat reflectors, e.g. separately-insertible reflecting walls **[1, 2006.01]**
9/22 • Arrangements for directing heat-exchange media into successive compartments, e.g. arrangements of guide plates **[1, 2006.01]**
9/24 • Arrangements for promoting turbulent flow of heat-exchange media, e.g. by plates (F28F 1/38 takes precedence; in general F15D) **[1, 2006.01]**
9/26 • Arrangements for connecting different sections of heat-exchange elements, e.g. of radiators (connecting different sections in water heaters F24H 9/14) **[1, 2006.01]**

**11/00 Arrangements for sealing leaky tubes or conduits** (stopping flow from or in pipes in general F16L 55/10) **[1, 2006.01]**
11/02 • using obturating elements, e.g. washers, inserted and operated independently of each other (F28F 11/06 takes precedence) **[1, 2006.01]**
11/04 • using pairs of obturating elements, e.g. washers, mounted upon central operating rods (F28F 11/06 takes precedence) **[1, 2006.01]**
11/06 • using automatic tube-obturating appliances **[1, 2006.01]**

**13/00 Arrangements for modifying heat transfer, e.g. increasing, decreasing** (F28F 1/00-F28F 11/00 take precedence) **[1, 2006.01]**
13/02 • by influencing fluid boundary (boundary-layer control in general F15D) **[1, 2006.01]**
13/04 • by preventing the formation of continuous films of condensate on heat-exchange surfaces, e.g. by promoting droplet formation **[1, 2006.01]**
13/06 • by affecting the pattern of flow of the heat-exchange media **[1, 2006.01]**
13/08 • • by varying the cross-section of the flow channels **[1, 2006.01]**
13/10 • • by imparting a pulsating motion to the flow, e.g. by sonic vibration **[1, 2006.01]**
13/12 • • by creating turbulence, e.g. by stirring, by increasing the force of circulation (F28F 13/08 takes precedence) **[1, 2006.01]**
13/14 • by endowing the walls of conduits with zones of different degrees of conduction of heat **[1, 2006.01]**
13/16 • by applying an electrostatic field to the body of the heat-exchange medium **[1, 2006.01]**
13/18 • by applying coatings, e.g. radiation-absorbing, radiation-reflecting; by surface treatment, e.g. polishing **[1, 2006.01]**

**17/00 Removing ice or water from heat-exchange apparatus [1, 2006.01]**

**19/00 Preventing the formation of deposits or corrosion, e.g. by using filters [1, 2006.01]**
19/01 • by using means for separating solid materials from heat-exchange fluids, e.g. filters **[6, 2006.01]**
19/02 • by using coatings, e.g. vitreous or enamel coatings **[1, 2006.01]**
19/04 • • of rubber; of plastics material; of varnish **[1, 2006.01]**
19/06 • • of metal **[1, 2006.01]**

**21/00 Constructions of heat-exchange apparatus characterised by the selection of particular materials [1, 2006.01]**
21/02 • of carbon, e.g. graphite **[1, 2006.01]**
21/04 • of ceramic; of concrete; of natural stone **[1, 2006.01]**
21/06 • of plastics material **[1, 2006.01]**
21/08 • of metal **[1, 2006.01]**

**23/00** **Features relating to the use of intermediate heat-exchange materials, e.g. selection of compositions [1, 2006.01]**

23/02 • Arrangements for obtaining or maintaining same in a liquid state **[1, 2006.01]**

**25/00** **Component parts of trickle coolers** (arrangements for increasing heat transfer F28F 13/00; controlling arrangements F28F 27/00) **[1, 2006.01]**

25/02 • for distributing, circulating, or accumulating liquid (spraying or atomising in general B05B, B05D) **[1, 2006.01]**

25/04 • • Distributing or accumulator troughs **[1, 2006.01]**

25/06 • • Spray nozzles or spray pipes **[1, 2006.01]**

25/08 • • Splashing boards or grids, e.g. for converting liquid sprays into liquid films; Elements or beds for increasing the area of the contact surface (packing elements in general B01J 19/30, B01J 19/32) **[1, 2006.01]**

25/10 • for feeding gas or vapour **[1, 2006.01]**

25/12 • • Ducts; Guide vanes, e.g. for carrying currents to distinct zones **[1, 2006.01]**

**27/00** **Control arrangements or safety devices specially adapted for heat-exchange or heat-transfer apparatus [1, 2006.01]**

27/02 • for controlling the distribution of heat-exchange media between different channels (arrangements of guide plates or guide vanes F28F 9/22, F28F 25/12) **[1, 2006.01]**

**99/00** **Subject matter not provided for in other groups of this subclass [2006.01]**

**F28G** **CLEANING OF INTERNAL OR EXTERNAL SURFACES OF HEAT-EXCHANGE OR HEAT-TRANSFER CONDUITS, e.g. WATER TUBES OF BOILERS** (cleaning pipes or tubes in general B08B 9/02; devices or arrangements for removing water, minerals, or sludge from boilers while the boiler is in operation, or which remain in position while the boiler is in operation, or are specifically adapted to boilers without any other utility F22B 37/48; removal or treatment of combustion products or combustion residues F23J; removing ice from heat-exchange apparatus F28F 17/00)

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**1/00** **Non-rotary, e.g. reciprocated, appliances** (F28G 3/00 takes precedence) **[1, 2006.01]**

1/02 • having brushes (brushes A46B) **[1, 2006.01]**

1/04 • having articulated tools, e.g. assembled in chain manner **[1, 2006.01]**

1/06 • having coiled wire tools, i.e. basket type **[1, 2006.01]**

1/08 • having scrapers, hammers, or cutters, e.g. rigidly mounted **[1, 2006.01]**

1/10 • • resiliently mounted **[1, 2006.01]**

1/12 • Fluid-propelled scrapers, bullets, or like solid bodies **[1, 2006.01]**

1/14 • Pull-through rods **[1, 2006.01]**

1/16 • using jets of fluid for removing debris (F28G 1/12 takes precedence) **[1, 2006.01]**

**3/00** **Rotary appliances [1, 2006.01]**

3/02 • having abrasive tools **[1, 2006.01]**

3/04 • having brushes (brushes A46B) **[1, 2006.01]**

3/06 • having articulated tools, e.g. assembled in chain manner **[1, 2006.01]**

3/08 • having coiled wire tools, i.e. basket type **[1, 2006.01]**

3/10 • having scrapers, hammers, or cutters, e.g. rigidly mounted **[1, 2006.01]**

3/12 • • resiliently mounted **[1, 2006.01]**

3/14 • • thrown into working position by centrifugal force **[1, 2006.01]**

3/16 • using jets of fluid for removing debris **[1, 2006.01]**

**5/00** **Cleaning by distortion** (by vibration F28G 7/00) **[1, 2006.01]**

**7/00** **Cleaning by vibration [1, 2006.01]**

**9/00** **Cleaning by flushing or washing, e.g. with chemical solvents** (appliances using jets of fluid for removing debris F28G 1/16, F28G 3/16) **[1, 2006.01]**

**11/00** **Cleaning by combustion processes, e.g. using squibs, using travelling burners [1, 2006.01]**

**13/00** **Appliances or processes not covered by groups F28G 1/00-F28G 11/00; Combinations of appliances or processes covered by groups F28G 1/00-F28G 11/00 [1, 2006.01]**

**15/00** **Details** (measuring thickness of deposit G01B) **[1, 2006.01]**

15/02 • Supports for cleaning appliances, e.g. frames **[1, 2006.01]**

15/04 • Feeding or driving arrangements, e.g. power operation **[1, 2006.01]**

15/06 • • Automatic reversing devices **[1, 2006.01]**

15/08 • Locating position of cleaning appliances within conduits **[1, 2006.01]**

15/10 • Masks for delimiting area to be cleaned **[1, 2006.01]**