

[54] TEMPERATURE CONTROL

[75] Inventors: **Robert Lewis Bickerdike**, Alton;
William Norman Mair, Farnham;
Evan Samuel Thomas, Farnborough,
all of England

[73] Assignee: **The Secretary of Defence in
Her Majesty's Government of the
United Kingdom of Great Britain
and Northern Ireland**, London,
England

[22] Filed: **July 9, 1973**

[21] Appl. No.: **377,658**

[30] Foreign Application Priority Data

July 14, 1972 United Kingdom..... 33072/72

[52] U.S. Cl. **165/81; 118/59; 118/69;
165/185; 219/462**

[51] Int. Cl. **F28f 7/02**

[58] Field of Search 219/462; 165/30, 47, 76,
165/168, 81, 185, 75/23, 135; 118/48-49.5,
69, 500-503

[56] References Cited

UNITED STATES PATENTS

2,955,184 10/1960 Grindrod 219/462 X

3,361,195 1/1968 Meyerhoff et al. 165/170 X
3,514,771 5/1970 Ehalt et al. 165/168 X

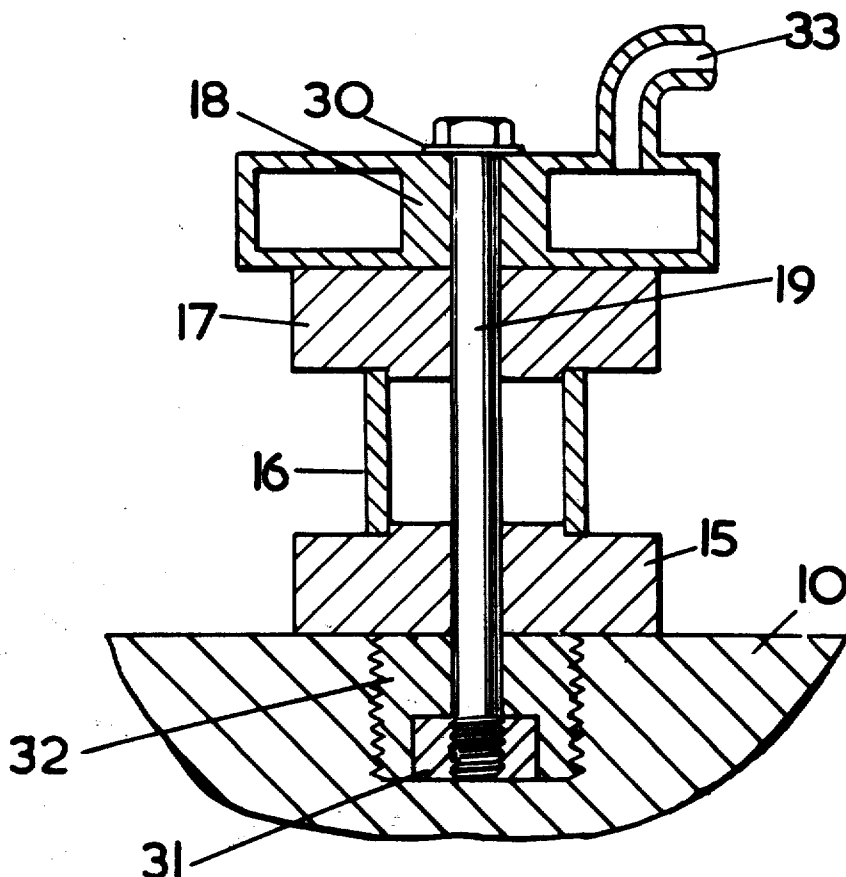
Primary Examiner—Morris Kaplan
Attorney, Agent, or Firm—Stevens, Davis, Miller &
Mosher

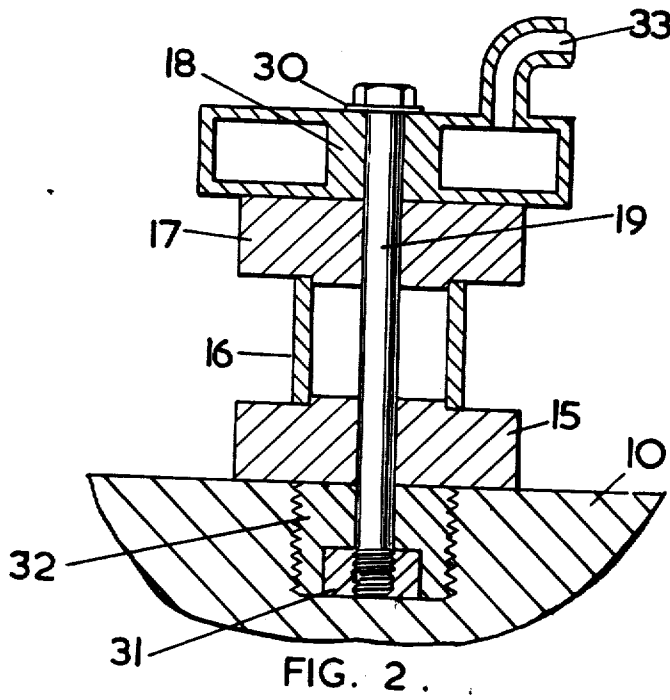
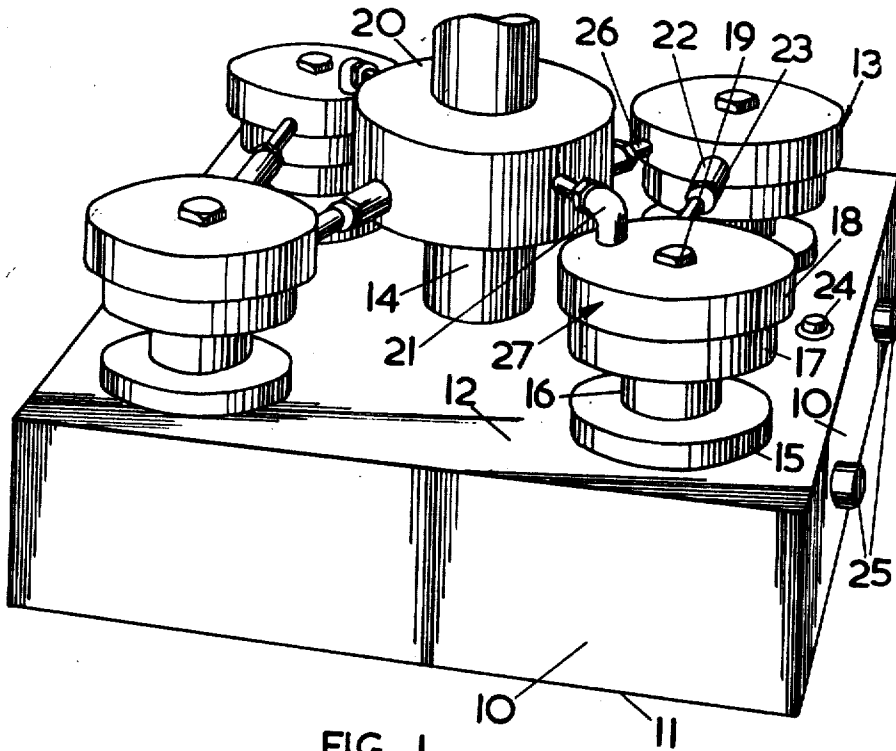
[57] ABSTRACT

The invention is concerned with temperature control at high temperatures and high heat fluxes and is particularly concerned with the temperature control of collectors of evaporated metal, using water as coolant.

A collector for the deposition of alloys from the vapour phase is described which includes a thick metal plate which has a first face and a second face opposite the first face; a plurality of heat sink members attached in efficient thermal contact with the said second face, the heat sink members being provided with internal channels for the passage of coolant; and flexible connecting means connecting at least some of the channels to allow circulation of coolant through at least some of the heat sink members.

5 Claims, 2 Drawing Figures





TEMPERATURE CONTROL

The present invention is concerned with temperature control at high temperatures and high heat fluxes.

In applications where high temperature and high heat fluxes are encountered difficulty is experienced in providing adequate cooling. One of the most convenient coolants is water but, since it boils at 100°C, difficulties (eg steam production) arise if it is used at temperatures much above 95°C. Accordingly problems are encountered if water is to be used as a coolant to maintain a constant temperature in excess of 100°C.

A particular instance of this occurs in apparatus for the production of metal alloys by the evaporation of components of the alloys and their deposition upon a temperature controlled collector. Frequently, to ensure a desired structure of property of deposit, particularly to ensure adequate adhesion of the deposit to the collector it is necessary to maintain the collector at a temperature in excess of 100°C. Such temperatures may exceed 250°C or even 300°C.

Embodiments of the present invention may permit a collector to have its temperature maintained at temperatures of the order of 300°C by use of water as a coolant.

Although specifically designed for temperature control of collectors of evaporated metal using water as coolant the present invention may be used in the temperature control of any body at a temperature in excess of the boiling point of any particular coolant selected and particularly at a temperature in excess of 100°C by use of water as coolant. In accordance with the present invention a temperature control device includes a body the temperature of which is to be controlled; a plurality of heat sink members attached in efficient thermal contact with the body, the heat sink members being provided with internal channels for the passage of a coolant; and flexible connecting means connecting at least some of the channels to allow circulation of coolant through at least some of the heat sink members and arranged to remain leak tight despite expansion or contraction of the apparatus due to heating.

Typical apparatus for the production of an alloy by deposition of its components from the vapour phase includes a heated source means from which the constituents are evaporated, a temperature controllable collector, and a removable shutter interposed between the source and the collector so that the metal vapour only impinges upon the collector when desired, the whole being enclosed in a controllable vacuum or low pressure system.

In accordance with an aspect of the invention apparatus for the production of an alloy by the deposition of its components from the vapour phase includes a temperature controllable collector having a thick metal plate which has a first face to receive the deposited alloy and a second face opposite the first face; a plurality of heat sink members attached in efficient thermal contact with the said second face, the heat sink members being provided with internal channels for the passage of a coolant; and flexible connecting means connecting at least some of the channels to allow circulation of coolant through at least some of the heat sink members and arranged to remain leak tight despite expansion or contraction of the apparatus due to heating.

All of the heat sink members may be on the same coolant circuit and preferably the coolant is water.

Generally the collector assembly comprising the collector itself and the attached heat sink members and coolant circulating means are designed for a specific temperature or temperature range at the collector face by use of known information regarding thermal conductivity of the materials, coefficients of expansion and expected heat flux at the collecting surface. The heat sink members are distributed to a predetermined pattern on the back of the collector so that the expected heat flux is transferred to the coolant, each heat sink member taking an appropriate quantity of heat.

A difficulty which arises is that under the influence of the temperature gradient across the collector the collector undergoes distortion and if removable heat sink members of a material different from the collector are used this distortion will tend to break the efficient thermal contact necessary for successful operation.

The heat sink members are preferably of a high thermally conductive material, for example copper, and in accordance with an aspect of the present invention the member, spacing and contact area of the heat sink members are selected so that the radii of curvature (r) of the collector and of the heat sink members caused by heat distortion at operating temperature are substantially the same as determined by the formula:

$$r = (K/a) Q$$

where K is thermal conductivity, a is the coefficient of linear expansion and Q is the heat flux per unit of contact area.

Advantageously the heat sink members are removably attached and in accordance with a further aspect of the present invention the heat sink members are attached to the collector by a bolt or like means of material having a lower coefficient of linear expansion than the material of the heat sink means so that as the temperature is raised the heat sink means is more firmly attached to the collector. It will of course be realised that the material of the bolt must have a coefficient of linear expansion and a strength such that it does not break under the strain imposed upon it by such differential thermal expansion.

A practical embodiment of the present invention will not be described by way of example only with reference to the accompanying drawings in which:

FIG. 1 is a general perspective view of a collector, and

FIG. 2 is a cross sectional view of one heat sink member.

Referring now to FIG. 1 the assembly includes a thick collector plate 10 of aluminium having a surface 11 for the deposit of the alloy and on the opposite surface 12, are heat sink members 13. The collector plate 10 is supported by a shaft 14 (the means of attachment of the shaft 14 to the collector 10 are not shown but are conventional). Each heat sink member 13 comprises a lower copper block 15, a copper tube 16, an upper copper block 17 and a stainless steel water compartment 18. All of these parts are held on to the collector plate 10 by means of a mild steel bolt 19.

The shaft 14 is provided with a water distribution housing 20 and pipes 21, 22 and 26 are provided to circulate water through the water compartments 18, each run of pipes being provided with a flexible vacuum seal 23.

The collector 10 is also provided with a thermocouple 24 by which the temperature can be monitored

and heaters 25 by which the collector 10 can be heated. In the collector illustrated there are two water circulations from the water distribution housing 20 by way of pipe 21 to heat sink means 27, pipe 22 to heat sink means 13 and finally by way of pipe 26 to the water distribution housing 20. A similar circulation serves the other two heat sink members. The electrical leads to the thermocouple 24 and heaters 25 and the water supply to and from the water distribution housing 20 are not shown but these are accommodated in conventional fashion on the shaft 14.

With reference now to FIG. 2 the heat sink member 13 is shown in section with the lower copper block 15, the copper tube 16, the upper copper block 17 and the stainless steel water compartment 18. A mild steel bolt 19 fitted with a washer 30, is screwed into a mild steel bolt 31. The bolt 31 is held in position in the collector plate 10 by means of an aluminium plug 32, consequently the mild steel bolt 19 maintaining the heat sink member 13 in contact with the collector plate 10. The water compartment 18 is hollow and has an inlet tube 33 by which the cooling water is introduced into the compartment, the exit tube is not visible in this section.

In operation the collector plate heats up and a temperature differential is established across the thickness of the plate resulting in distortion to a particular radius of curvature. The thickness and diameter of the lower copper block 15 is selected so that at the operating temperature the temperature difference across it is such that it will adopt the same radius of curvature as the aluminium collector plate 10. The mild steel bolt 19 has a lower coefficient thermal expansion than the copper and therefore as the heat sink member heats up it is urged more strongly against the collector ensuring an efficient thermal contact.

The temperature of the collector face 11 is a function of the rate of heat removal and may be adjusted by changing the copper tube 16. The thicker and shorter the copper tube 16 is, the faster heat is conducted away and therefore the lower the temperature of the collector face 11 for a given incident heat flux. A material of different thermal conductivity than copper may also be substituted rather than altering the dimensions of tube 16.

The pipes 22 and 26 illustrated for the water circulation as such as could be employed if the collector was to be rotated for use in a "layering" process as disclosed in UKP No. 1,265,965. If the collector is to be stationary, or subject only to slight movement relative to the source to remove slight unevenness of deposit,

simple arcuate pipes may be used to compensate for differential thermal expansion.

What we claim is:

1. In a device having a temperature gradient there-across, as from deposition of an alloy from the vapour phase, a temperature controllable collector having a thick metal plate which has a first face adapted to receive deposited alloy and a second face opposite the first face;

10 a plurality of heat sink members attached in efficient thermal contact with said second face, the heat sink members being provided with internal channels for the passage of coolant; and

flexible connecting means connecting at least some of the heat sink members and arranged to remain leak tight despite expansion or contraction of the apparatus due to heating and

wherein the number, spacing and contact area of the heat sink members are selected so that the radii of curvature (r) of the said second face of the thick metal plate and of the contracting faces of the heat sink members caused by thermal distortion at the operating temperature are substantially the same as determined by the formula: $r = (K/a)Q$, where K is thermal conductivity, a is the coefficient of linear thermal expansion and Q is the heat flux per circuit area.

2. Apparatus as claimed in claim 1 and wherein the heat sink members are distributed to a predetermined pattern on said second face of the thick metal plate, so that the expected heat flux is transferred to the coolant, each heat sink member taking an appropriate quantity of heat.

35 3. Apparatus as claimed in claim 2 and wherein the heat sink members are attached to said thick metal plate by a bolt or like means having a coefficient of linear expansion lower than the heat sink means so that as the temperature is raised the heat sink means is more firmly attached to said thick metal plate.

40 4. Apparatus as claimed in claim 3 wherein each heat sink member includes a replaceable member through which a major part of the heat flux flows in operation so that the rate of heat flow and hence the operating temperature may be altered by replacing said replaceable members with similar members of differing dimensions and/or differing thermally conductive properties.

5. Apparatus as claimed in claim 4 wherein connecting means are arcuate pipes.

* * * * *