Feb. 22, 1966 L. KOPITO 3,236,205

HIGH TEMPERATURE FURNACE

Filed April 24, 1961 2 Sheets-Sheet 1

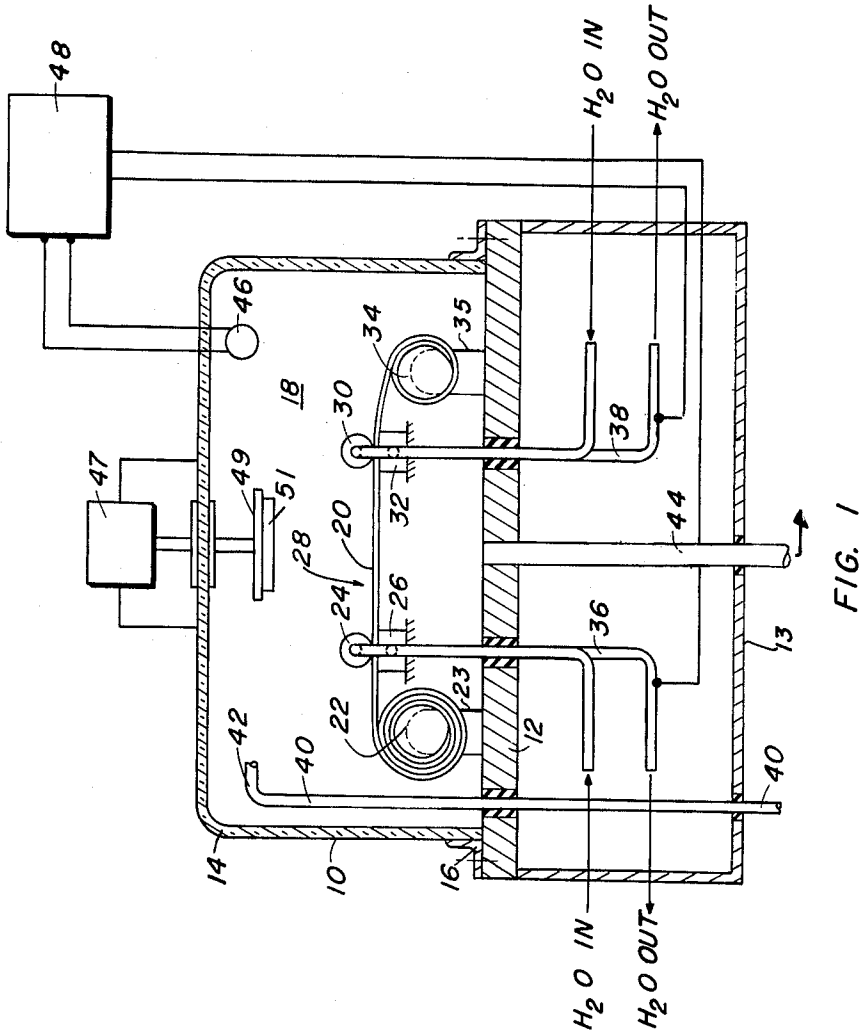


FIG. 1

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Filed April 24, 1961 2 Sheets-Sheet 2

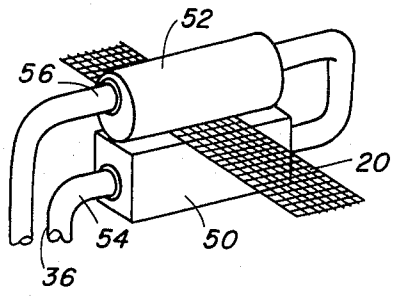


FIG. 2

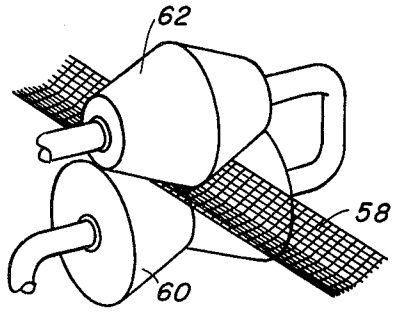


FIG. 3

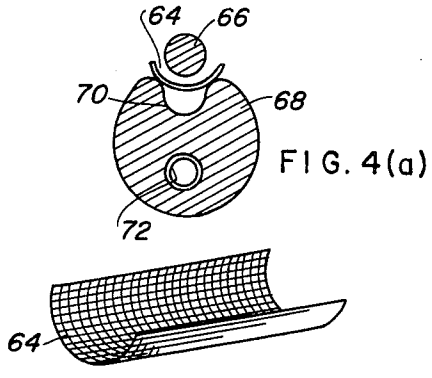


FIG. 4(a)

FIG. 4(b)

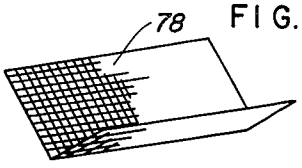


FIG. 5(b)

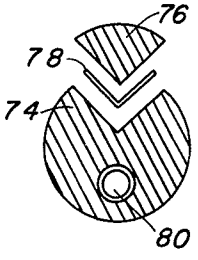


FIG. 5(a)

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HIGH TEMPERATURE FURNACE

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The present invention relates to electric generation and application of heat and, more particularly, to processes and devices by which temperatures of between 3000 and 6600° F. may be reached and applied efficiently and rapidly. The efficient and rapid conversion of electricity into heat is useful in a variety of applications where possible contamination resulting from chemical combustion is to be avoided. However, many electric furnaces suffer from insulating and power supply problems which become serious in many applications, i.e. in educational and research applications requiring simple control and ready access, in heat treating applications where extremely rapid increase in temperature is required in order to avoid certain microstructure formation at intermediate temperatures, etc.

The primary objects of the present invention are to provide processes and devices involving the use of electrically energized graphite fabric as a heat source designed to reach an elevated temperature from an ordinary temperature within an extremely short time, to convert electricity to heat with unusual efficiency, to provide a heating zone that may be readily observed, to be temperature controlled by a simple electrical system and to enable the application of heat from its source directly to a variety of high melting point materials. In the illustrated device this graphite fabric is mounted by fluid cooled carbon connectors for supporting the graphite fabric and applying an electrical current thereacross. The cross-sectional profiles of the connectors are such that they shape the graphite fabric section carried thereby into a container within which materials to be heat treated my be placed. The graphite fabric is enclosed within a suitable housing having an inert atmosphere and a window through which the heating zone may be observed.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

For a fuller understanding of the nature and objects of the present invention, reference should be had to the following detailed description, taken in connection with the accompanying drawing, wherein:

FIG. 1 is a partly mechanical, partly electrical assembly and schematic view of a device embodying the present invention;

FIG. 2 is a persective view of a component of the dtvice of FIG. 1;

FIG. 3 is a perspective view of a modification of a component of the device of FIG. 1;

FIG. 4(*a*) is a cross-sectional view of a modification of a component of the device of FIG. 1;

FIG. 4(*b*) is a fragmentary perspective view of the fabric section of FIG. 4(*a*);

FIG. 5(*a*) is a cross-sectional view of a modification of a component of the device of FIG. 1; and

FIG. 5(*b*) is a fragmentary perspective view of the fabric section of FIG. 5(*a*).

Generally, the illustrated device comprises a housing providing a base upon which the operating components of the device are mounted, a removable cover in association with the base for enclosing the operating components, a sheet of graphite fabric which may be energized to a temperature ranging up to 6600° F., a plurality of carbon connectors by which the graphite fabric may be mechanically mounted and electrically energized, an inert atmosphere which tends to minimize deterioration of the graphite fabric and a detector for measuring minor variations of the temperature of the graphite fabric in order to control the current therethrough. The device is capable of effecting a process by which a variety of metals and ceramics may be melted or evaporated without contamination while being held by the graphite fabric directly.

A preferred graphite fabric is woven from fibers of high purity graphic carbon having a tensile strength from 50,000 to 100,000 p.s.i. The fibers themselves may be produced by processing carbonaceous materials at temperatures up to 5400° F. Such graphite fibers have high thermal conductivity and good electrical conductivity. Chemically, such graphite fibers are composed of approximately 99.09%+ carbon and approximately 0.04% ash containing magnesium, aluminum, calcium, iron, manganese, silicon, boron, copper, nickel and sodium. This material sublimes at approximately 6600° F. (3650° C.) without melting. The filaments have an average diameter ranging from 0.00005 to 0.001 inch. The fabric has a thread count per inch ranging from 20 to 30, a gage ranging from 0.01 to 0.04 and number of filaments per ply ranging from 1 to 2,000. The graphite connectors for supplying the graphite section are themselves supported by cooling tubes for flowing water continuously therethrough in order to control heat transmission from the graphite cloth to the housing while enabling flow of electricity through the cloth. The inert atmosphere in which the graphite fiber is disposed, for example, is a noble gas such as argon or a stable non-oxidizing gas such as nitrogen or carbon dioxide. The pressure of the gas preferably ranges from slightly above atmospheric to approximately 75 p.s.i. In practice, the fabric is supplied with from 200 to 15,000 watts per square inch of fabric in order to produce a temperature in excess of 3000° C. within approximately one second.

In reference now to the drawing, the illustrated device comprises a housing **10** within which the operating components of the device are mounted and enclosed. Housing **10** includes a base **12** and an inverted cover **14** supported thereon and sealed thereto by a suitable flanged rim **16**. Base **12** and cover **14** define a chamber **18** for enclosing a graphite fabric sheet **20**. Base **12** is composed of a suitable metal such as steel and cover **14** is composed of a suitable transparent vitreous material such as Pyrex, vicor or quartz.

Graphite sheet **20** extends from a supply roll **22** between a pair of carbon, preferably graphite, grips **24**, **26** into a heating region **28** and from heating region **28** between a pair of carbon, preferably graphite, grips **30**, **32** to a takeup spool **34**. A pair of metal conduits **36** and **38** are provided to support grips **24**, **26** and **30**, **32**, respectively, and to apply a suitable alternating or direct current across the graphite sheet. As will be apparent to persons skilled in the art, metal conduits **36** and **38** are electrically isolated from base **12** by suitable insulation (not shown). Lower portions of the conduits and various electrical connections are enclosed between base **12** and a casing **13**. Supply roll **22** and take-up spool **34** are supported on suitable insulating mounts **23** and **35**, which are affixed to base **12**. Supply roll **22** and take-up spool **34**, as shown, are manually notable when cover **14** is removed to advance fresh sheet **20** into operative position. A suitable gas inlet **40** is provided in order to inject a noble gas such as argon or an inert gas such as nitrogen or carbon dioxide into chamber **18** through a vent **42**. Vent **42** is directed obliquely toward the periphery of cover **14** in order to provide a vortex of gas which protects cover **14** from the heat emitted by fabric **20**. This gas is exhausted from cham-

ber 18 through a suitable exhaust outlet 44. This gas preferably is carbon dioxide which strongly absorbs infrared radiation and thereby protects the housing from the heat radiation generated by fabric 20. A suitable optical pyrometer 46 is provided in order to detect the heat emitted by fabric 20 and thereby to control a variable voltage supply 48 so that the power applied across conduits 36 and 38 through fabric 20 remains constant.

Mounted on cover 14 is a motor having a shaft projecting through the cover into chamber 18. At the inner end of this shaft is a mount 49 for carrying a workpiece 51. Workpiece 51 may be coated with material evaporated from graphite fabric 20 while in direct contact therewith. Various metals such as copper and vitreous materials such as glass have been vaporized when supported by the graphite fabric at 6000° F. by the passage of sufficient electrical current therethrough. The resulting vapor produces an even coat on workpiece 51 when it is rotated continuously by motor 47. In evaporation applications, preferably vent 40 is closed and chamber 28 is exhausted through outlet 44 to a pressure of less than approximately one mm. Hg.

The configuration of one pair of grips 24, 26 and 30, 32 is shown in FIG. 2 as including a graphite clamping block 50 and a graphite clamping cam 52. Block 50 is fixed to one of the reverse bends of conduit 36 as at 54 and cam 52 is rotatably mounted on the other of the reverse bends of conduit 36 as at 56. It is apparent that as graphite fabric sheet 20 is advanced between cam 52 and block 50, at some point it may be securely clamped therebetween. The arrangement is such that material to be melted or evaporated by means of the illustrated system, may be placed upon graphite fabric sheet 20 and thereafter a current may be transmitted therethrough to heat the graphite fabric sheet as well as the material placed thereupon to a suitable high temperature which is determined by the power transmitted through the graphite fabric sheet.

Other arrangements of clamping grips are shown in FIGS. 3, 4(*a*) and 5(*a*). In FIG. 3, graphite fabric sheet is shaped as at 58 to define a V-shaped cross-section by a pair of rollers 60 and 62. Roller 60 presents a V-shaped cross-sectional profile that is re-entrant and roller 62 presents a V-shaped cross-section that is outwardly projecting. The two profiles snugly mesh in order to impart to the fabric a desired boat-like contour for the reception of any suitable material to be melted or evaporated. FIG. 4(*a*) illustrates the formation of a graphite fabric boat 64 of semi-circular profile formed by a pair of carbon grips 66 and 68. Grip 66 is in the form of a rod of substantially circular cross-section and grip 68 is provided with a re-entrant portion 70 in which grip 66 may be seated. It is apparent that the seating of grip 66 in re-entrant portion 70 of grip 68 causes the fabric section to assume the contour shown at 64. In the above discussed way, carbon grip 68 is provided with a suitable cooling conduit 72. FIG. 5(*a*) illustrates a pair of grips 74 and 76 analogous in all respects to grips 68 and 66 except that their seated profiles are angular rather than circular in order to provide graphite fabric 78 with a V-shaped cross-sectional profile. In the above discussed way, carbon grip 74 is provided with a suitable cooling conduit 80. Each of the structures of FIGS. 3, 4 and 5 is characterized by sufficient mechanical play to permit the carbon grips to be at least slightly movable apart and is characterized by a profile orientation that permits the carbon fabric to be advanced into position between the grips in such a way as to assume the indicated configuration. For clarity, the grips of FIGS. 4 and 5 are shown as exploded views but it will be understood that, in practice, opposite faces of the carbon fabric are contacted by adjacent inner surfaces of the grips.

The following non-limiting examples will further illustrate the performance of the process of the present invention in conjunction with graphite fabric sections shaped in accordance with FIGS. 2, 3, 4(*a*) and 5(*a*).

Example I

In a specific process embodying the present invention, the graphite fabric weighs approximately 7.5 ounces per square yard, the count of the graphite fabric is approximately 27 x 25 threads per inch, the gage of the graphite fabric is approximately 0.0001, the denier and ply of the graphite fabric is 950/1, the filaments per ply are 1440, the filament diameter is approximately 0.9. Three grams of copper resting on a two square inch section of this fabric was melted at a temperature of approximately 3000° F. by energizing the fabric section with approximately 1200 watts of electricity per square inch for a period of approximately two seconds.

Example II

In another example of this process, with the same graphite fabric section as that of Example I, a gram of asbestos resting on the fabric section was fused at a temperature of approximately 3500° F. by energization with about 1500 watts of electricity per square inch for a period of approximately two seconds.

In operation, with cover 14 removed, a fresh section of graphite fabric 20 is positioned between grips 24, 26 and 30, 32 by suitable rotation of takeup and supply spools 22 and 34. Thereafter a material to be melted or evaporated is placed within the holding region defined between pairs of grips 24, 26, and 30, 32. The cover then is replaced and sealed to base 12 by means of rim 16. Thereafter, while water coolant is supplied to the grips, the grips and consequently the graphite fabric are energized by electrical current. Bolometer 46, operating through variable power supply 48, controls the amount of current flowing between the grips and consequently the amount of heat generated by the graphite fabric.

Since certain changes may be made in the foregoing device without departing from the scope of the invention herein involved, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. An electric device comprising a housing defining a chamber, said housing including a pair of fluid coolant conduits mounted on said housing within said chamber, one of said conduits carrying a first holder, the other of said conduits carrying a second holder, a graphite fabric section connected between said first holder and said second holder, means for flowing said fluid coolant through said conduits, means for applying electrical power between said first holder and said second holder, said first holder and said second holder each including a pair of holder elements, each of said elements presenting a profile that is at least partly skew with respect to the axes of said holders, whereby said graphite fabric section defines a boat for the reception of material to be heated.

2. An electric device comprising a housing defining a chamber, said housing including a pair of fluid coolant conduits mounted on said housing within said chamber, one of said conduits carrying a first holder, the other of said conduits carrying a second holder, a graphite fabric section connected between said first holder and said second holder, means for flowing said fluid coolant through said conduits, means for applying electrical power between said first holder and said second holder, and a detector for determining the temperature of said graphite fabric section in order to provide a signal and there is provided control means for adjusting said power means in response to said signal.

3. An electric heating device comprising a housing defining a chamber, said housing including a pair of fluid coolant conduits mounted on said housing within said

chamber one of said conduits carrying a first holder, the other of said conduits carrying a second holder, a graphite fabric section connected between said first holder and said second holder, means for flowing said fluid coolant through said conduit and means for applying electrical power between said first holder and said second holder, each of said first holder and said second holder including a pair of holder elements, each of said elements presenting a profile that is bent, whereby said graphite fabric section defines a boat for the reception of a material to be heated.

4. The device of claim 3 wherein said chamber is evacuated to low pressure and wherein a rotatable mount is provided for presenting a workpiece for coating by material evaporated from said graphite fabric section.

5. The device of claim 3 wherein means are included for providing said chamber with an inert gas.

6. The device of claim 3 wherein there is provided a detector for determining the temperature of said graphite fabric section in order to provide a signal and there is provided control means for adjusting said power means in response to said signal.

7. The device of claim 6 wherein said power means is mechanically connected across said fluid coolant conduits.

8. An electrical device comprising a housing defining a chamber, said housing including a pair of fluid coolant conduits mounted on said housing within said chamber, one of said conduits carrying a first holder, the other of said conduits carrying a second holder, a heating stratum connected between said fluid conduits, means for flowing said fluid coolant through said conduits and means for applying electrical power between said first holder and said second holder, wherein said first holder and said second holder each includes a pair of holder elements, each of said elements presenting a profile that is at least partially skew with respect to the axes of said holders, whereby said heating stratum defines a boat for the reception of materials to be heated.

9. The device of claim 8 wherein there is provided a detector for determining the temperature of said heating stratum in order to provide a signal and there is provided control means for adjusting said power means in response to said signal.

10. An electric heating device comprising a housing defining a chamber, said housing including a pair of fluid coolant conduits mounted on said housing within said chamber, one of said conduits carrying a first holder, and the other of said conduits carrying a second holder, a heating section connected between said first holder and said second holder, means for flowing said fluid coolant through said conduit and means for applying electrical power between said first holder and said second holder, each of said first holder and said second holder including a pair of holder elements, each of said elements presenting a profile that is bent, whereby said heating section defines a boat for the reception of a material to be heated.

11. An electric heating device comprising a housing defining a chamber, said housing including closure means for said housing permitting access into said housing when open and sealing said housing when closed, first holding means and second holding means in said housing, a graphite fabric section connected between said first holding means and said second holding means, and power means for supplying electrical current between said holding means, said holding means being composed of carbon, each of said holding means including a pair of holding elements, each of said elements presenting a profile that is at least partially skew with respect to the axes of said holding elements, whereby said graphite fabric section defines a boat for the reception of a material to be heated.

References Cited by the Examiner

UNITED STATES PATENTS

1,401,303	12/1921	Baldwin	219—252 X
2,445,866	7/1948	Wilson et al.	219—155
2,479,346	8/1949	Goodnow	219—155
2,695,582	11/1954	Sparks	117—106
2,784,115	3/1957	Brinsmaid et al.	117—106
2,822,575	2/1958	Imbert et al.	156—192
2,902,574	9/1959	Gudmondson et al.	117—107
2,930,879	3/1960	Scatchard	117—107
2,956,256	10/1960	Sheer	339—112 X
2,978,666	4/1961	McGregor	339—117 X
2,985,860	5/1961	Morey	219—528 X
3,024,761	3/1962	Bertelsen	118—49.1
3,095,506	6/1963	Dewey et al.	219—531 X
3,120,597	2/1964	Maloof et al.	219—531

FOREIGN PATENTS

715,227	8/1954	Great Britain.

OTHER REFERENCES

Mechanical Engineering, "Graphite Now Produced in Flexible Textile Form—Application Limitless," vol. 81, June 1959, p. 121.

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