July 30, 1968 D. ROMAN 3,395,241

GRAPHITE HEATING ELEMENT FOR ELECTRIC RESISTANCE FURNACE

Filed Sept. 6, 1966 2 Sheets-Sheet 1

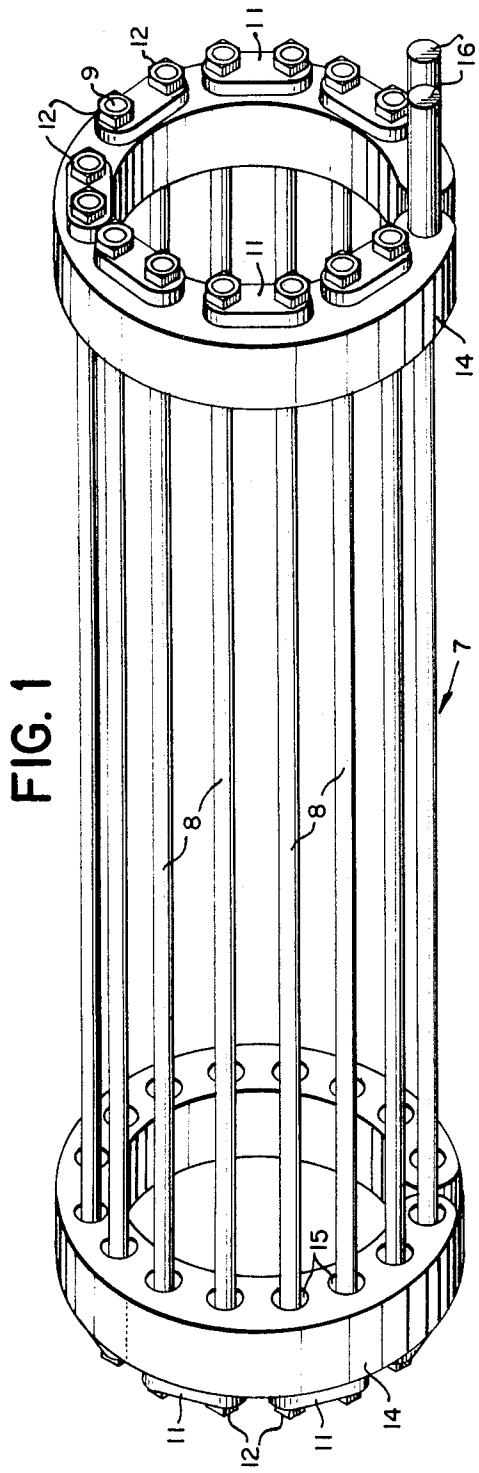


FIG. 1

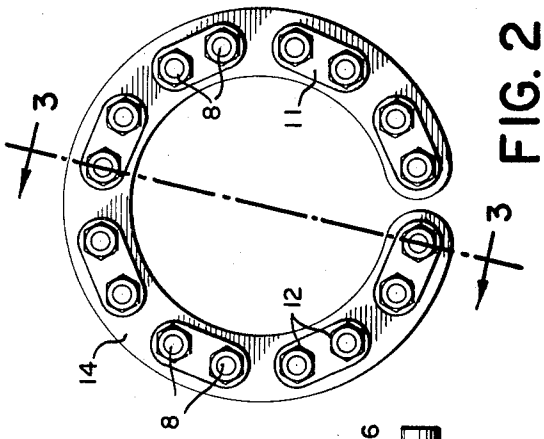


FIG. 2

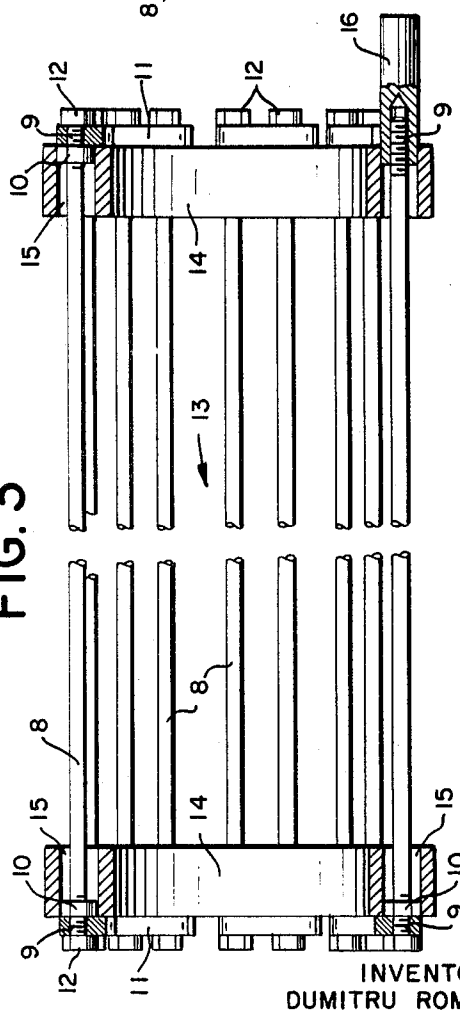


FIG. 3

INVENTOR
DUMITRU ROMAN

BY Nolte and Nolte
ATTORNEYS

July 30, 1968 D. ROMAN 3,395,241

GRAPHITE HEATING ELEMENT FOR ELECTRIC RESISTANCE FURNACE

Filed Sept. 6, 1966 2 Sheets-Sheet 2

FIG. 4

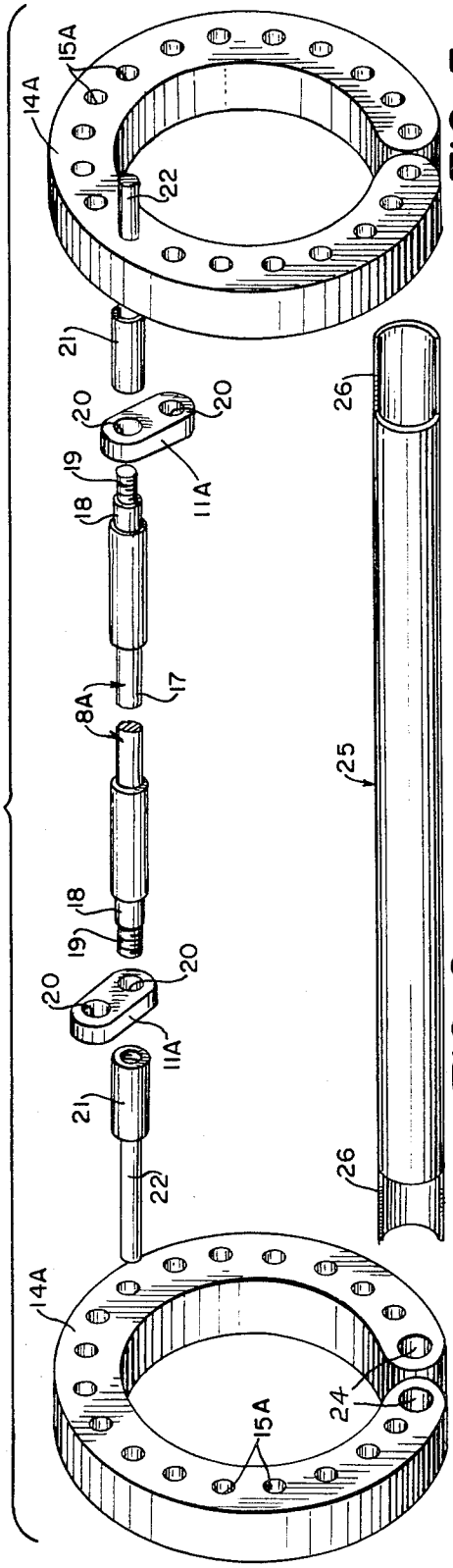


FIG. 5

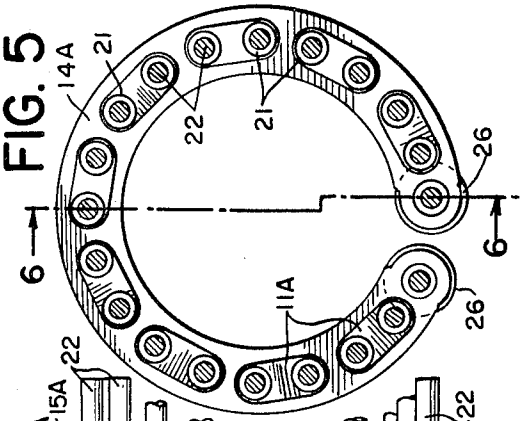
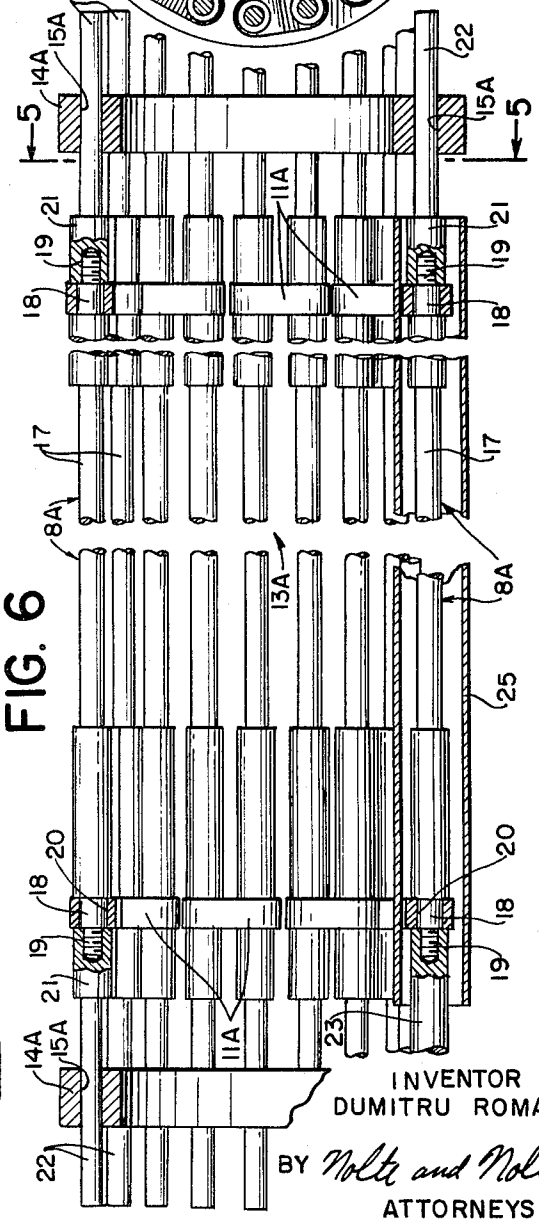


FIG. 6



INVENTOR
DUMITRU ROMAN

BY Nolte and Nolte
ATTORNEYS

United States Patent Office

3,395,241
Patented July 30, 1968

3,395,241

GRAPHITE HEATING ELEMENT FOR ELECTRIC RESISTANCE FURNACE

Dumitru Roman, Fairfield, New South Wales, Australia, assignor to Australian Atomic Energy Commission, Coogee, New South Wales, Australia

Filed Sept. 6, 1966, Ser. No. 577,367
Claims priority, application Australia, Sept. 3, 1965, 63,610/65
8 Claims. (Cl. 13—25)

ABSTRACT OF THE DISCLOSURE

A tubular squirrel-cage array of end-threaded graphite heating rods in an electric resistance furnace are electrically interconnected by graphite bridging elements in series circuit. The rods are supported at their opposite ends by substantially annular refractory mounts and enclose a heating zone.

This invention concerns electric resistance furnaces and particularly such furnaces capable of heating to a high temperature of the order of 2,400° C.

For experimental work and for the heat treatment and melting of refractory materials, it is necessary sometimes to provide temperatures up to and in excess of 2,000° C. and to operate in a controlled atmosphere. Above 1,200° C. the conventional resistance furnaces use noble metals of the platinum group for the furnace element windings. Such furnaces are extremely expensive and suffer from the disability of the unavoidable presence of "hotspots," which lead to early failure and frequent replacement of the resistance heating element. Above 2,000° C. electric induction furnaces are used. These suffer from excessive thermal instability which makes temperature control extremely difficult.

To overcome these problems graphite and refractory metal (tungsten and molybdenum) resistance furnaces are used and operate in inert atmosphere. Such furnaces are frequently formed with a heating element of tubular shape, often as a hollow cylinder. Because of the high electric currents used, heavy expensive power equipment is required. Very low electrical conductivity experiments and temperature measurements with non-earthed thermocouples, that is, in general, measurements required to be made under non-inductive conditions become virtually impossible.

The principal object of the present invention is to design and construct, for operation in a relatively high temperature range, graphite electric resistance furnaces which overcome these problems.

In one general form, therefore, the invention provides a heating element rod unit for a multiple rod electric resistance furnace, comprising a rod of medium ohmic material, an intermediate portion in the rod length to provide a heating zone, a thread on one end portion of the rod, a bridging element mountable upon an end portion of the rod, means for connecting the bridging element to an end portion of the rod of another rod unit to provide for assembly of the two rod units as a step in the construction of a heating element assembly, and a nut for screwing said end portion of the rod to retain the bridging element upon the rod.

Furthermore, the invention provides a heating element assembly comprising a plurality of said heating element rod units interconnected by their bridging elements in a squirrel cage formation with the resistance rods electrically connected in series, and spaced refractory mounts supporting the end portions of the resistance rods.

Two specific embodiments of the invention are illustrated in the accompanying drawings, in which:

FIG. 1 is a perspective view of a first form of the heating element;

FIG. 2 is an end elevation;

FIG. 3 is a longitudinal section on the line **3—3** in FIG. 2;

FIG. 4 is a fragmentary perspective view of a second form of the invention, only one rod being shown;

FIG. 5 is an end elevation of the form shown in FIG. 4; and

FIG. 6 is a longitudinal section on the line **6—6** in FIG. 5.

A first embodiment of the invention is shown in FIGS. 1, 2 and 3 in which the electric resistance furnace **7** is designed to function at temperatures within the range of 1,000° C. to 2,400° C. This furnace **7** will consist of a plurality of novel heating element rod units each of which is formed from a rod **8** of medium ohmic material, such as graphite. Although the use of this material is highly desirable, especially for high temperature furnaces, other materials can be used, according to the maximum operating temperature desired, and in such an event it might be necessary to use an appropriate furnace atmosphere.

In certain circumstances, it may be desirable for the central portion of each rod to be formed or machined to possess a reduced cross-sectional dimension. This feature is shown in the second embodiment and will be described later. In this respect the factors concerned with the actual cross-sectional dimension include the length of the working, heating zone, the furnace temperature and the power requirements of the furnace **7**.

The heating element rod units **8** are threaded at each end **9** and nuts **10** are mounted thereon to form a shoulder. A bridging element **11** formed of a rectangular graphite block provided with two spaced holes fits over the threaded ends **9** of adjacent rods **8**.

Nuts **12** are provided for screwing to the threaded ends **9** of the rods to secure the bridging elements **11** and rods **8** in an assembled condition. It is preferred that these nuts **10** and **12** be also formed of graphite, particularly in the case of high temperature furnaces, as refractory metals, such as tungsten or molybdenum could react with the graphite rods **8** at high temperatures to produce carbides with resulting undesirable effects.

A heating element assembly for an electric resistance furnace **7** can be formed by the assembly of a plurality of heating element rod units **8** of the above kind. By the invention this is achieved through an assembling connection of the units **8** in a squirrel cage formation with the resistance rods electrically connected in series. This is effected by the interconnection of rods **8** and their associated bridging elements **11**. That is to say that the rod units **8** are disposed symmetrically in parallel physical relationship about the axis of the furnace **7**.

The typical heating element assembly shown in FIGS. 1, 2 and 3 consists of 16 graphite rod units **8** approxi-

mately 11 inches long and 5/32 of an inch in diameter in the heating zone **13** and arranged in squirrel cage formation. Each rod **8** is threaded at its ends **9** for approximately 1 inch of its length over which graphite bridge elements **11** are located and secured in position by graphite nuts **10** and **12** screwed to the ends **9** of the rods **8**.

Such an assembly, although quite rigid in itself, preferably is supported by refractory rings **14** at the end portions of each rod **8**. These mounts **14** are made of stabilized zirconia for operation above 1,800° C. and of alumina for operation below these temperatures. These refractory rings **14** will in most cases be constructed as flat annuli provided with an annular row of apertures such as holes **15** bored therethrough. The graphite rods **8** are adapted to pass through corresponding holes **15** in the two rings **14** so that they will be supported therebetween by their end portions **9**.

When incorporated in the furnace **7** the heating element assembly is contained in a shell (not shown) using reflectors and insulating material in the conventional manner, provided the shell can be dismantled easily and permits atmospheric control using either vacuum or an inert gas. With this construction of furnace a central compartment **13** is designed within the rod **8** array of the heating element assembly within which may be positioned a suitable platform or grating (not shown) for the location of goods to be heated. For the application of electric power to the assembly, power terminals **16** will be connected to either end of the serial connection of the rod units **8** through the interconnection of the bridging elements **11**.

A furnace so constructed with heating element rod units **8** of a particular grade of graphite (known as WWH) would have the following operational characteristics:

Resistance at room temperature ohms	4.5
Resistance at 1600° C. do	3.5
Current amps	20
Power kva	1.5
Uniform temperature zone at 1,200° C. percent of length of furnace	30

A second form of the invention is shown in FIGS. 4, 5 and 6. In this embodiment an array of twenty rod elements **8A** are adapted to be supported in refractory rings **14A** provided with apertures **15A** as before. The intermediate section of each rod **8A** is reduced in diameter as at **17** to increase its electrical resistance thereat so that the heating zone **13A** will be raised to a higher temperature than the extremities of said rods **8A**. At said rod evtremities a shoulder section **18** of reduced diameter is formed and the rod ends are further reduced in diameter and threaded as shown at **19**. Bridging elements **11A** are each provided with two holes **20**, which are a push fit over the shoulders **18** of the rods **8A**, so that all twenty rods **8A** can be joined together in a sequential series by means of said bridging elements **11A**.

Tubular nuts **21** are threadably engaged with the ends **19** of the rod elements **8A** and said nuts **21** are reduced in diameter at their free ends **22** so that each said reduced end **22** is a push fit in the holes **15A** in the insulating refractory rings **14A**. The array of rods **8A** are thus supported in a squirrel cage formation by means of the tubular nut ends **22** which rest within the holes **15A** in the rings **14A**.

The ring **14A** can also be adjustably moved away, for a short distance, from the heating zone **13A** when a higher than usual temperature is required in said zone **13A**.

The arrangement shown also facilitates the replacement of a broken rod **8A**. To replace a rod, the tubular nut **21** at each end is unscrewed to free the rod. A new rod **8A** can now be inserted into the bridging elements **11A** and the tubular nuts **21** engaged with its threaded ends, without disturbing the rest of the rods **8A**.

Terminal connection tubes **23** are internally threaded to engage the ends of the series of rods **8A**; enlarged holes **24** being provided in one ring element to receive said tubes **23**. It will be seen that there will be a much greater potential difference between the terminal rods supported in the holes **24**, than between any other pair of adjacent rods **8A**. Alumina tubes **25** are therefore provided to surround said terminal rods to prevent arcing between them. The ends **26** of the tubes **25** are also relieved as shown in FIG. 4 so that said tubes can also shield the ends of the rings **14A**.

Whereas several embodiments have now been described it is to be understood that other forms and modifications are feasible which fall within the scope of this invention. The principles of this invention may be applied to either horizontal or vertical furnaces.

What I claim is:

1. A heating element for an electric resistance furnace comprising a tubular assembly of heating element rod units to form a heating chamber therein, each rod unit comprising a graphite rod having an intermediate portion in the rod length for producing heat in a heating zone within said chamber and opposite end portions, each of a pair of said rods having a free end, a plurality of bridging elements each mounted at one end on an end portion of a corresponding one of said rods and at the other end on an end portion of a corresponding other of said rods to electrically connect said rod units in series circuit, a power terminal extension threaded on the free end of one pair of said rods, and substantially annular refractory mounts supporting all of said rod units at the end portions of said heating of said heating rods.

2. A heating element as claimed in claim **1**, wherein the intermediate portion of each rod is of reduced cross-sectional dimension so that said portion of each rod is of higher resistance per unit length than elsewhere along the length of the rod.

3. A heating element as claimed in claim **1**, further comprising a retaining nut threaded on each end portion of each of said rods, each of said retaining nuts having a longitudinally extending stem and wherein the refractory mounts are two rings each having apertures formed therethrough, each of said rings supporting a respective end of the rod assembly, the stems of the nuts at each end of the assembly passing through the apertures and thereby supported by the corresponding one of said rings.

4. A heating element as claimed in claim **1**, further comprising a retaining nut threaded on each end portion of each of said rods.

5. A heating element as claimed in claim **4**, wherein the intermediate portion of each rod is of reduced cross-sectional dimension so that said portion of each rod is of higher resistance per unit length than elsewhere along the length of the rod.

6. A heating element as claimed in claim **4**, wherein the retaining nuts on each end of said rods are on the same side of the corresponding bridging elements, each heating rod is of uniform thickness throughout its length and a positioning nut is threaded on each of its threaded end portions on the side of the corresponding bridging elements opposite that of the corresponding retaining nuts to form an abutment against which the corresponding bridging element is held by its corresponding retaining nut.

7. A heating element as claimed in claim **6**, wherein said bridging elements have apertures formed therethrough, the refractory mounts are two rings each having a plurality of apertures formed therethrough, each of said rings supporting a respective end of the rod assembly, the end portions of the heating rods passing through the apertures formed through said rings and through the apertures through said bridging elements.

8. A heating element for an electric resistance furnace comprising a plurality of heating element rod units arranged as a squirrel-cage assembly to enclose a tubular

heating chamber, each of said rod units comprising a graphite rod, a thread formed on the opposite end portions of each rod, each of a pair of said rods having free ends, a plurality of graphite bridging elements each electrically interconnecting the corresponding end portion of a pair of adjacent rods corresponding to that bridging element so that the plurality of rods are electrically connected in series circuit, graphite retaining nuts threaded on the ends of said rods to retain the bridging elements in position, electrical terminal means threaded on the free end of one pair of said rods, and a pair of spaced substantially annular refractory rings each supporting corresponding end portions of the heating rods.

References Cited

UNITED STATES PATENTS

3,004,090	10/1961	Donovan et al.	13—25
2,491,579	12/1949	Poland	13—25 XR
2,768,277	10/1956	Buck et al.	219—427
3,108,171	10/1963	Vary	13—25 XR
3,128,325	4/1964	Andersen et al.	13—20

ROBERT K. SCHAEFER, *Primary Examiner.*

M. GINSBURG, *Assistant Examiner.*