May 22, 1962 H. H. GOLDSTAUB ETAL 3,036,187

FLEXIBLE ELECTRIC HEATER

Filed Dec. 20, 1960

2 Sheets-Sheet 1

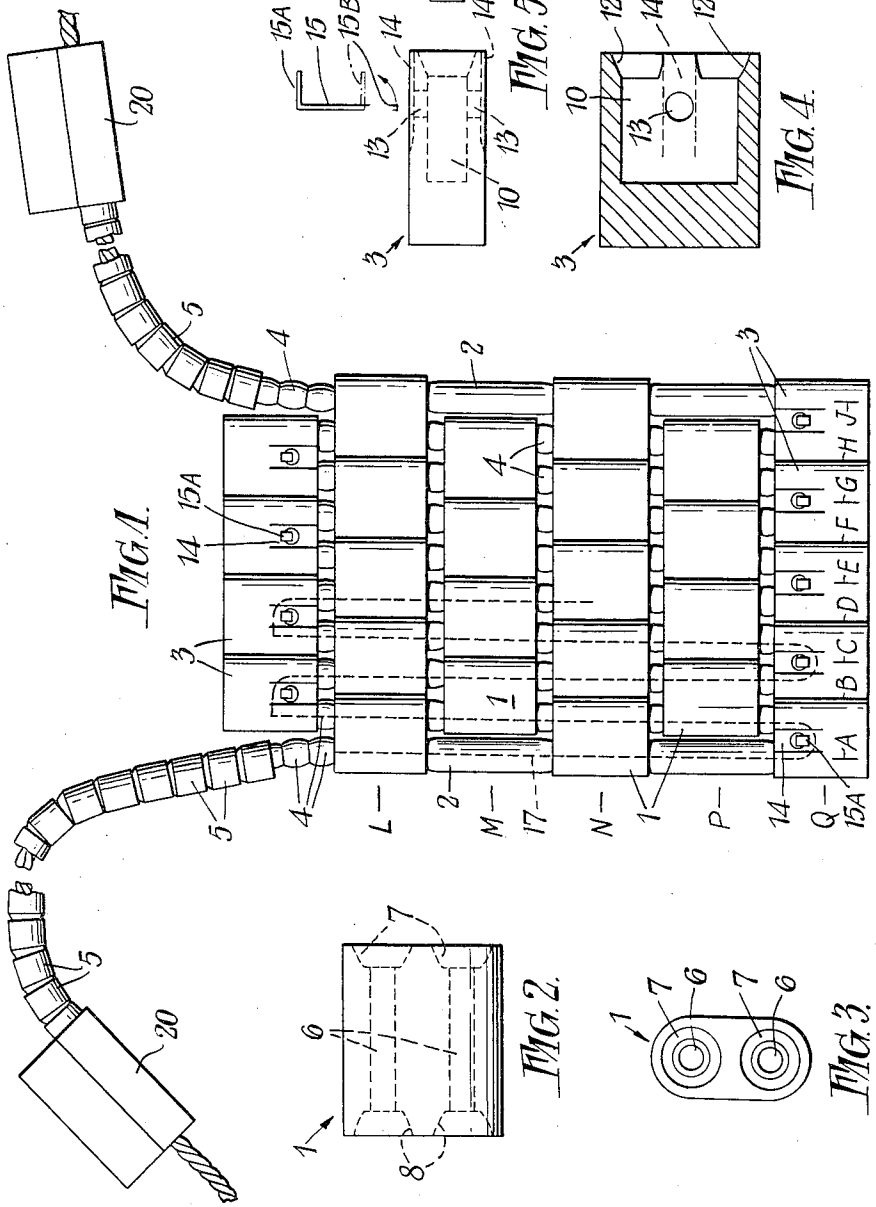

FIG. 1.

FIG. 5.

FIG. 4.

FIG. 2.

FIG. 3.

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Filed Dec. 20, 1960 2 Sheets-Sheet 2

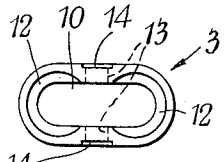

FIG. 6.

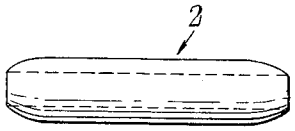

FIG. 8.

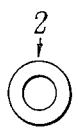

FIG. 9.

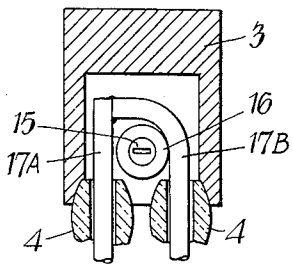

FIG. 7.

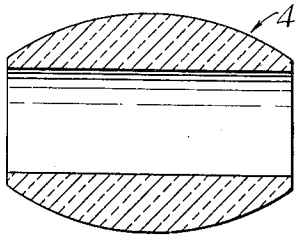

FIG. 10.

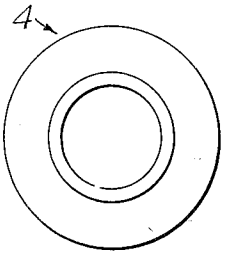

FIG. 11.

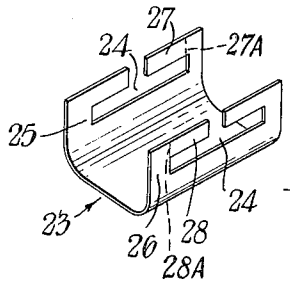

FIG. 14.

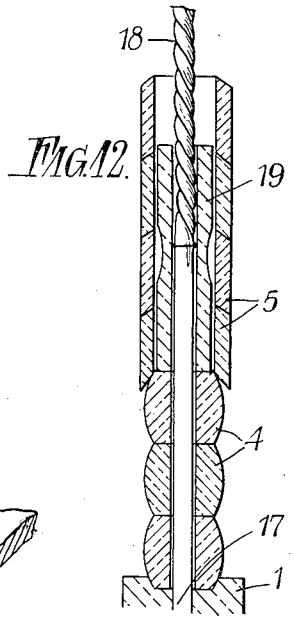

FIG. 12.

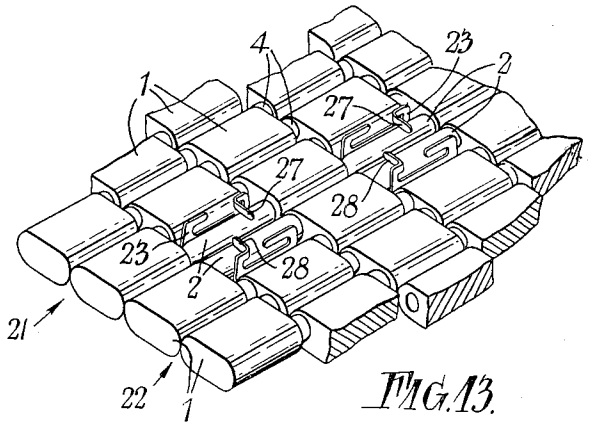

FIG. 13.

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3,036,187

FLEXIBLE ELECTRIC HEATER

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5 Claims. (Cl. 219—19)

This invention relates to a flexible electric heater.

It is often required to stress-relieve cast or welded bodies or structures by means of flexible electric heaters wrapped around them or otherwise placed in close proximity to the parts to be heated. It is often the case that the flexible heater required has to be especially designed having regard to the area to be heated and when it has been used for the job in hand it is of no further use unless, perhaps, there is another job requiring a similarly dimensioned heater. It is desirable to provide a heater made up of a plurality of individual heating devices which can be uncoupled from one another, after use, and used again, either individually or coupled together to form a heater larger or smaller than the original heater.

According to the present invention there is provided a flexible electric heater consisting of: a first flexible electric heating device comprising similar blocks of heat-resistant material arranged in a first row, a plurality of intermediate rows and a last row, all parallel and each having the blocks therein spaced apart whilst the blocks in each row are staggered in relation to the blocks in the next row and the blocks are positioned such that a portion of a block in one row projects between two blocks in the next row, further blocks similar to one another in the first and last rows positioned one between each two adjacent ones of the first-mentioned blocks in those rows and forming with all the first-mentioned blocks a plurality of parallel files of blocks extending perpendicularly to said rows, the extent of each of said further blocks in the direction of the files being smaller than the corresponding extent of each of the first-mentioned blocks and such that all the files are substantially co-extensive with one another, portions of the blocks defining two spaced, parallel passages through each of the first-mentioned blocks extending in the direction of said rows and one passage through each of said further blocks also extending in the direction of said rows, resistance wire threaded through the passages in the first-mentioned blocks and extending from block to block parallel to the rows, first through a block in one row, then through a block in an adjacent row, then through a block in said one row and so on such that each block in each intermediate row has two portions of said resistance wire threaded therethrough and each of the first-mentioned blocks disposed in the first and last rows has one portion of said resistance wire threaded therethrough and the first-mentioned blocks are mechanically linked together by the wire to form a flexible structure, further resistance wire consisting of two stretches which are parallel to the rows and threaded through the remaining passages in the first-mentioned blocks, and the passages in said further blocks, in the first and last rows thereby linking said further blocks to said structure; a second flexible electric heating device constructed in accordance with the foregoing definition of the first flexible heating device and disposed adjacent the latter device with its files of blocks in line with the files of blocks of the first heating device and with one of its end rows of blocks closely adjacent one of the end rows of blocks of the first heating device; and coupling means mechanically coupling the two heating devices together by engaging at least some of the blocks in the two heating devices in the end rows which are adjacent as aforesaid.

For a better understandng of the invention and to show how the same may be carried into effect, reference will

now be made to the accompanying drawings in which:

FIGURE 1 is a side view of an electric heating device,

FIGURE 2 is a side view of a first heat-resistant block forming part of the device shown in FIGURE 1,

FIGURE 3 is an end view of the same block,

FIGURE 4 is a sectional side view of a second block of the heating device,

FIGURE 5 is a plan view of the second block showing also parts which are fitted therein during assembly of the heating device,

FIGURE 6 is an end view of the second block,

FIGURE 7 is a further sectional side view of the second block showing resistance wire and other parts inserted therein,

FIGURE 8 is a side view of a third block forming part of the heating device,

FIGURE 9 is an end view of the same block,

FIGURE 10 is a sectional side view of a bead forming part of the heating device,

FIGURE 11 is an end view of the bead,

FIGURE 12 is a sectional view illustrating an electrical joint in the heating device,

FIGURE 13 is a perspective view of parts of two heating devices, according to the earlier figures, which are mechanically coupled together, and

FIGURE 14 is a perspective view of a coupling device.

The heating device which is shown in FIGURE 1, and of which details are shown in FIGURES 2 to 12, includes blocks and beads made of a material capable of withstanding temperatures in excess of 600° C. The material may, for example, be sintered aluminum oxide or steatite. There are three different kinds of blocks, designated 1 to 3 and three different kinds of beads, designated 4, 5 and 16.

For the sake of simplicity, only a very small heating device, containing a correspondingly small number of blocks, is illustrated. The blocks are arranged in nine rows, a first row A, seven intermediate rows B to H and a last row J. In the end rows A and J there are two blocks 1, two blocks 2 and one block 3, whereas in each intermediate row there are two blocks 1 and one block 3. In each intermediate row the blocks constituting the row are in line and spaced well apart and between each two adjacent blocks there projects a portion of one block from each of the two adjacent rows. The blocks also form files L to N, P and Q, which extend perpendicularly to the rows and each have four or five blocks therein. It will be noted that the extent of each block 2 in the direction of the files (i.e. in the horizontal direction considering FIGURE 1) is less than the corresponding extent of each block 1 or 3 and is such that all the files are substantially co-extensive. Thus the castellated confiuration which would exist at the two sides of the heating device if all the blocks were of the same extent, measured along the files, is avoided.

Each block 1 is formed with two parallel passages 6 (see FIGURES 2 and 3) having their mouths 7 widened and rounded to give concave surfaces 8. The mouths 7 receive the correspondingly rounded ends of the beads 4, which are shown in detail on an enlarged scale in FIGURES 10 and 11, or, in the case of the first and last rows of blocks, the rounded ends of the blocks 2, which are shown in FIGURES 8 and 9. This arrangement facilitates flexure of the heating device.

Each block 3 is formed with a deep recess 10 extending from one end. The mouth of the recess 10 is flared at two positions 12 to form seatings for the ends of beads 4 or blocks 2, as the case may be. Two passages 13 extend into the recess 10 from opposite sides of the block and those sides are also formed with shallow recesses 14 which extend to one end of the block. Associated with each block 3 is an initially L-shaped nickel-chromium or

molybdenum strip 15, of rectangular cross-section, and a bead 16 in the form of a short hollow cylinder which can be inserted in the recess 10 with the passage through the bead in line with the passages 13 in the block.

A number of lengths of resistance wire (17), consisting of nickel-chromium or molybdenum, are connected together to form a heating element. Each length of wire is hairpin shaped and it is threaded through the passages in the blocks and the beads in the manner indicated in dotted lines in FIGURE 1. The two extreme ends of each length of wire are connected by welding to the ends of two adjacent lengths of wire and the welded ends are inserted into the recesses 10 in the blocks 3 at one end of the heating device, i.e. the end shown uppermost in FIGURE 1. FIGURE 7 shows the end of one length of wire 17A welded to the end of another length of wire 17B. All the lengths of wire are connected together in the same way to form a continuous heating element. After insertion of the welded connection into the recess 10 in a block 3, the bead 16 is fitted into the loop or bight of wire and the strip 15 is inserted through one of the passages 13, the passage through the bead 16 and then the other passage 13, whereupon it is bent as shown in dotted lines at the top of FIGURE 5. The two end portions 15A and 15B then lie in the two recesses 14 in the block 3. At the end of the heating device shown lowermost in FIGURE 1, the bights in the hairpin lengths of wire are similarly retained in the blocks 3.

FIGURE 12 shows how the resistance wire 17 is connected to a flexible lead 18 with the aid of a nickel-chromium or molybdenum tube 19 which is fused to the wire 17 and to the lead 18, the tube and the part of the lead 18 projecting out of it being surrounded by beads 5 the ends of which nest into one another. A block 20 fixed to the lead 18 prevents the beads 5 from slipping off the lead.

FIGURE 13 shows portions of two electrical heating devices 21 and 22 constructed according to FIGURES 1 to 12. It will be seen that the files of blocks in the two heating devices are in line and that the side rows of blocks in the two heating devices are closely adjacent one another and so arranged that a block 2 in one device is opposite a block 2 in the other device. The two heating devices are coupled together by means of coupling members 23. One of the coupling members is shown in FIGURE 14. It is formed from a rectangular sheet of stainless steel or of a heat-resistant alloy formed with T-shaped recesses 24 at both ends and bent to form a U having arms 25 and 26. The coupling member is applied to the two heating devices such that the arm 25 is inserted between two blocks 1 and 2 in one device and the arm 26 is inserted between the adjacent two blocks 1 and 2 in the other device, whereupon the portion marked 27 at the end of one arm of the U is bent, about a line 27A that is parallel to the length of the arm, towards the end of the other arm and the portion marked 28 is similarly bent about a line 28A. Thus, each block 2 is partly embraced by the coupling member and the assembly of the two heating devices is held together by the coupling members. The assembly does not have large gaps where the two heating devices are joined together, as would be experienced if the sides of the heating devices were castellated, so non-uniform heating (of the article to be heated) does not occur at the joins. Naturally, any desired number of the heating devices may be mechanically coupled together, side by side, in the same way. They may also be electrically connected together, if desired, that is to say their heater elements may be connected in series or in parallel.

By coupling the heating devices together in the described manner, it is possible to build a large electric heater from a number of small component heating devices. When the large heater has been used, it may be dismantled by removing the coupling members 23, whereafter the individual heating devices may be used again.

Since the ends of each heating device are not castellated, two or more heating devices may conveniently be placed end to end if required, again without leaving gaps in the assembly.

A flexible electric heater formed of two or more individual heating devices, as described above, can be used for stress-relieving cast or welded bodies or structures and it can also be wrapped around a pipe or a container and used to heat the same.

We claim:

1. A flexible electric heater consisting of: a first flexible electric heating device comprising similar blocks of a first kind made of heat-resistant material arranged in a first row, a plurality of intermediate rows and a last row, all rows being parallel and each having the blocks therein spaced apart whilst the blocks in each row are staggered in relation to the blocks in the next row and the blocks are positioned such that a portion of a block in one row projects between two blocks in the next row, further blocks of a second kind similar to one another positioned one between each two adjacent ones of the blocks of the first kind in the first and last rows and forming with all the blocks of the first kind a plurality of parallel files of blocks extending perpendicularly to said rows, the extent of each of said blocks of the second kind in the direction of the files being smaller than the corresponding extent of each of the blocks of the first kind and such that all the files are substantially co-extensive with one another, portions of the blocks defining two spaced, parallel passages through each of the blocks of the first kind extending in the direction of said rows and one passage through each of said blocks of the second kind also extending in the direction of said rows, electric heater element material threaded through the passages in the blocks of the first kind and extending from block to block parallel to the rows, first through a block in one row, then through a block in an adjacent row, then through a block in said one row and so on such that each block in each intermediate row has two portions of said heater element material threaded therethrough and each of the blocks of the first kind disposed in the first and last rows has one portion of said heater element material threaded therethrough and the blocks of the first kind are mechanically linked together by the heater element material to form a flexible structure, further heater element material consisting of two stretches which are parallel to the rows and threaded through the remaining passages in the blocks of the first kind in the first and last rows and the passages in said blocks of the second kind thereby linking said blocks of the second kind to said structure; a second flexible electric heating device constructed in accordance with the foregoing definition of the first flexible heating device and disposed adjacent the latter device in side-to-side relation thereto with its files of blocks in line with the files of blocks of the first heating device and with the blocks in one of its end rows of blocks closely adjacent the blocks in one of the end rows of blocks of the first heating device; and coupling means mechanically coupling the two heating devices together, said coupling means comprising a plurality of substantially U-shaped coupling members each of which has first and second portions partly embracing a block in one heating device and a block in the other heating device, respectively, which blocks are adjacent as aforesaid.

2. A flexible electric heater consisting of: a first flexible electric heating device comprising similar blocks of a first kind made of heat-resistant material arranged in a first row, a plurality of intermediate rows and a last row, all rows being parallel and each having the blocks therein spaced apart whilst the blocks in each row are staggered in relation to the blocks in the next row and the blocks are positioned such that a portion of a block in one row projects between two blocks in the next row, further

blocks of a second kind similar to one another positioned one between each two adjacent ones of the blocks of the first kind in the first and last rows and forming with all the blocks of the first kind a plurality of parallel files of blocks extending perpendicularly to said rows, the extent of each of said blocks of the second kind in the direction of the files being smaller than the corresponding extent of each of the blocks of the first kind and such that all the files are substantially co-extensive with one another, portions of the blocks defining two spaced, parallel passages through each of the blocks of the first kind extending in the direction of said rows and one passage through each of said blocks of the second kind also extending in the direction of said rows, electric heater element material threaded through the passages in the blocks of the first kind and extending from block to block parallel to the rows, first through a block in one row, then through a block in an adjacent row, then through a block in said one row and so on such that each block in each intermediate row has two portions of said heater element material threaded therethrough and each of the blocks of the first kind disposed in the first and last rows has one portion of said heater element material threaded therethrough and the blocks of the first kind are mechanically linked together by the heater element material to form a flexible structure, further heater element material consisting of two stretches which are parallel to the rows and threaded through the remaining passages in the blocks of the first kind in the first and last rows and the passages in said blocks of the second kind thereby linking said blocks of the second kind to said structure; a second flexible electric heating device constructed in accordance with the foregoing definition of the first flexible heating device and disposed adjacent the latter device in side-to-side relation thereto with its files of blocks in line with the files of blocks of the first heating device and with the blocks in one of its end rows of blocks closely adjacent the blocks in one of the end rows of blocks of the first heating device; and coupling means mechanically coupling the two heating devices together, said coupling means comprising a plurality of coupling members each of which is made of sheet material and is bent substantially in the

form of a U but has at the free end of each arm of the U a portion that is bent out of the arm, about a line that is parallel to the length of the arm, towards the other arm, each coupling device having a block in one heating device and a block in the other heating device disposed side-by-side between the two arms of the U.

3. A heater according to claim 1 and further comprising portions of said blocks of the first kind defining flared and rounded mouths of said passages, elongate spacer beads which separate the adjacent blocks of the first kind in adjacent rows and which have the heater element material threaded therethrough, and rotund end portions of the bands inserted in said mouths and cooperating therewith to facilitate flexure of the heater.

4. A heater according to claim 1 and further comprising in each heating device a plurality of heat-resistant blocks of a third kind, these being equal in number to the rows and positioned at one end of alternate rows of the mentioned blocks and at the opposite end of the remaining rows, portions of said blocks of the third kind defining two parallel passages therein through which said heater element material enters the blocks of the third kind, and connections within at least some of said blocks of the third kind between individual parts constituting adjacent parallel stretches of said heater element material, whereby said heater element material within each individual heating device is of serpentine form.

5. A heater according to claim 4, having loops of heater element material formed in each of said blocks of the third kind where two parallel stretches of heater element material meet, a bead within each loop, portions of each block of the third kind defining an aperture therethrough extending perpendicularly to said rows and to said files, and an elongate fastening member extending through each aperture and the associated bead to hold the heater element material within the block.

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