APPARATUS FOR TRANSFERRING HEAT TO AND FROM A MASS

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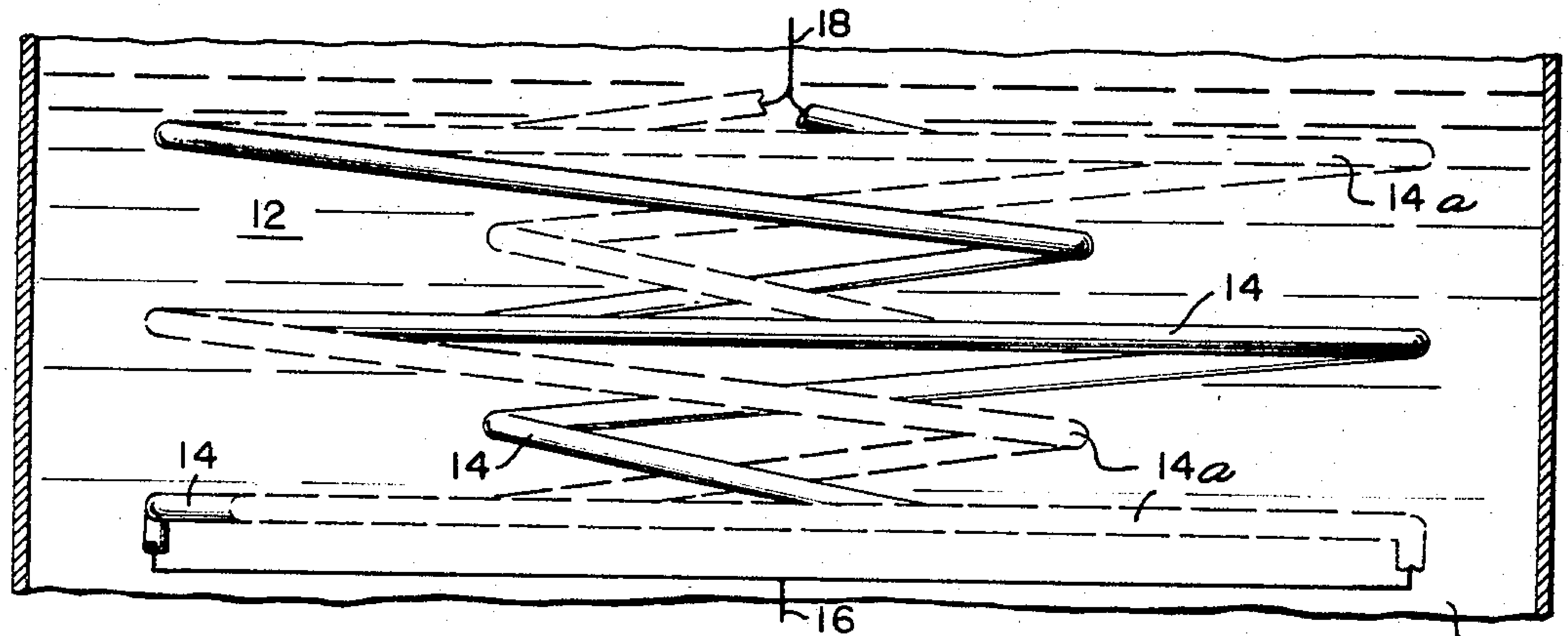

FIG. 2.

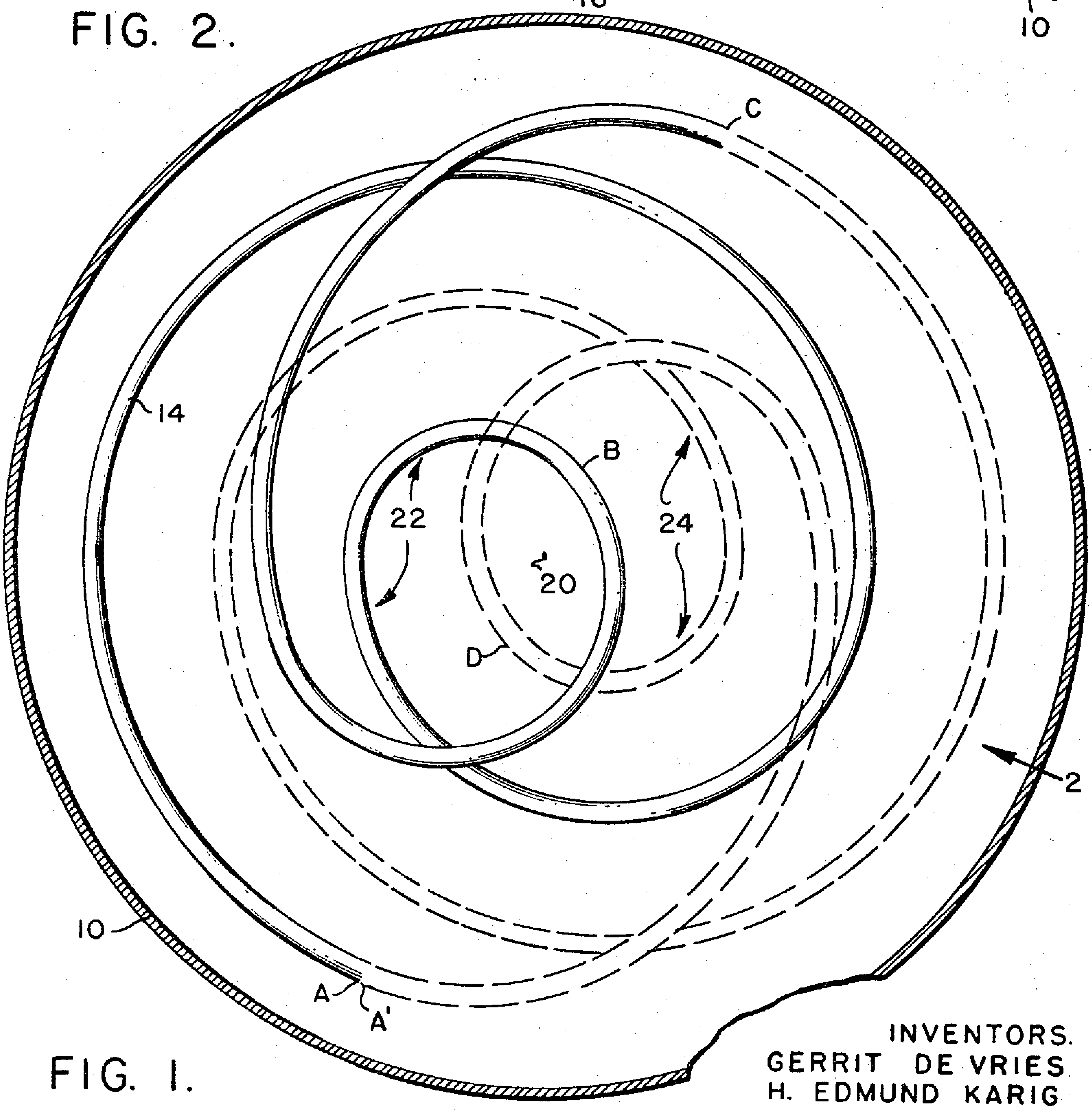

FIG. 1.

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APPARATUS FOR TRANSFERRING HEAT TO AND FROM A MASS

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ABSTRACT OF THE DISCLOSURE

Water tube type steam boiler in which a plurality of parallel connected angularly indexed identical tubes are disposed in a molten salt bed, the tubes being so interlaced in layers to transfer heat uniformly from the salt bed in progressive layers from bottom to top as the salt bed solidifies.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to steam boilers and more particularly to improvements in boilers of the type disclosed in patent application of H. Edmund Karig and Gerrit De Vries for Underwater Molten Salt Heat Storage Boiler, Ser. No. 500,389, filed Oct. 21, 1965.

In the application referred to, a steam boiler is disclosed for use in a steam propelled underwater vehicle, the boiler comprising a molten salt bed containing a steam generating coil. As the coil extracts heat from the salt bed it solidifies, first at the bottom of the salt bed, and then progressively toward its top. When completely solidified and cooled to a temperature at which no more heat may be extracted for generating steam at a desired temperature, superheated steam from an available steam source is passed through the coil, remelting the salt bed and raising it to a desired temperature above solidification temperature and the steam generating cycle is repeated. The molten salt bed thus comprises a heat sink from which heat may be extracted for a period of time after which heat must be added to the heat sink, differing from conventional boilers in which heat is continuously supplied and continuously extracted. For simplicity of disclosure, the steam coil in such application is illustrated as a single cylindrical helix and is claimed broadly in combination with other boiler features. It also alludes to a preferred type of steam coil comprising a plurality of parallel spaced flat coils each in the form of an Archimedean spiral which are connected together as one continuous coil. As will subsequently appear, the present invention relates to the specific construction and arrangement of a plurality of interlaced coils of the type broadly alluded to in such application.

One of the objects of the present invention is to provide a steam coil arrangement for use in a molten heat sink which will more uniformly extract heat from the sink in progressive layers from its bottom to its top.

Another object is to provide a plurality of coils, forming separate but parallel circuits which are interlaced in such manner that one circuit compensates for the tendency of another circuit to nonuniformly extract heat from the sink.

Still further objects, advantages and salient features will become apparent from the description to follow, the appended claims, and the accompanying drawing, in which:

FIG. 1 is a horizontal section through a steam boiler embodying the subject of the invention; and

FIG. 2 is a vertical section as viewed in the direction of arrow 2, FIG. 1.

The attainment of the objects is dependent upon certain concepts and design parameters, the enumeration of which, at this point, will provide a better understanding of the invention to subsequently be described in detail:

(a) There must be more than one tube and each tube should be as equally spaced from another as possible,

(b) The tubes should fit the molten heat sink mass and be uniformly distributed in it,

(c) Each tube should be longer than the mass, particularly where a large number of small straight tubes is undesirable or the mass is of nonuniform cross section,

(d) The tubes should progress through the mass always from a cooler portion to a hotter portion,

(e) All tubes should be identical in configuration, cross section, and length,

(f) The tubes should be interlaced so that at any zone in the mass there is more than one heat extraction circuit.

(g) For ease of fabrication, sharp bends in the tubing should be avoided.

Referring now to the drawing and first to FIG. 2, cylindrical container **10**, analogous to the container disclosed in the application referred to, contains a molten salt or salt mixture **12**, in which is embedded a plurality of coils **14**, **14***a* only two being shown for simplicity of disclosure but which may be any number desired. Both tubes are joined to a common feed water supply **16** at their lower ends and to a common steam outlet **18** at their upper ends.

The construction of coils **14**, **14***a* can best be understood by a description of the manner in which they are fabricated and assuming, first, that only one coil is employed. Referring to FIG. 1 and starting at point A, tube **14** is bent into the form of a flat spiral of decreasing radius of curvature about axis **20** for about 540° to point B. From point B to point C it is inclined upwardly through about 360° and a continuing spiral of increasing radius of curvature. At point C it starts a second flat spiral, parallel to the plane of the first flat spiral, continuing (shown in phantom lines) and thence with a decreasing radius of curvature to point D, the extent of this portion also being about 540°. At point D it is again inclined upwardly through about 360° to a point A′, spaced two planes above A, its point of beginning. The tube is then bent into further pairs of adjacent coils, as described, until the entire stack is of desired height. It will thus be apparent that the stack of coils consists of repetitive sets, each set consisting of at least two flat spiraled coils disposed in spaced parallel planes, each coil being spirally bent around the axis for about 540° and joined by an inclined spiral portion extending about 360° around the axis, the uppermost coil having a like inclined portion for joining the beginning of the next set.

Since one coil circuit would not satisfy the design parameters previously set forth, two or more identical coil circuits are required. It will now be assumed that two circuits are desired. Two separate supplies of tubing are fed to the bending machine with the two tubes disposed together, thus forming two coiled circuits, as previously described in the bending of a single tube. (This bending procedure is necessary since two or more coil circuits cannot be interlaced if bent separately.) They are then rotated relatively 180° so that both tubes have interlaced portions in each of the spaced planes. They would appear in plan the same as in FIG. 1 with loop **22** axially misaligned with loop **24** in the first plane, loops **22** and **24** again being axially aligned with their next succeeding like loops in the third plane where they again repeat themselves.

If X number of tubes are desired, where X is 3 or more, two alternate modes of bending and indexing are possible to interlace the tubes. In the first mode, and assuming for example, that 4 tubes are desired, the 4 tubes are fed together to the bending machine and bent in the first layer as described for a single tube. They then rise to the second layer with a loop, like **24**, misaligned 90° from the point of beginning (instead of 180°). In the third layer the next loop is misaligned 180° and in the fourth layer it is misaligned 270°. After bending the tubes they are then indexed 90° relative to each other so that in each layer there would be 4 loops like **22** and **24** forming a four leaf clover arrangement. In this mode of bending and interlacing the number of layers from a reference point of beginning to a point of repetition is equal to the number of tubes, X.

In the other mode of bending and interlacing, all of the tubes, say 4, are fed to the bending machine in the same manner as described for two tubes (loops **22**, **24** being misaligned 180°). They are then indexed 90° relative to each other. In this mode of bending and interlacing there are, again, four loops like **22**, **24** in each layer but completion of all bending, before repetition, occurs in two layers rather than in four layers. In this mode of bending and interlacing, completion of all bending, before repetition, occurs in two layers regardless of the number of tubes.

With the exception of the specific coil circuits above described, the construction is the same as disclosed in the identified application which includes a pressure equalizing tube communicating ambient pressure with the space above the salt bed, suitable insulation around container **10**, and the necessary valves for connecting the coils to a steam supply when the salt bed is to be remelted.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. Heat exchange apparatus for use in a cylindrical vessel having a longitudinal axis and containing a substantially noncirculating material, the improvements, comprising:

(a) a stack of hollow coils embedded in said material in parallel spaced planes perpendicular to said axis,

(b) said stack comprising a set of layers adapted to be connected with a like identical set,

(c) said set comprising a plurality of separate tubes, forming separate parallel circuits and comprising a number of layers, each tube being in the form of a plurality of parallel spaced spirals each disposed in a spaced layer, the plurality of tubes being interlaced and spaced apart in each layer, all tubes being of identical shape between a beginning and an end point, at which latter its shape is repeated, the tubes being relatively rotated about said axis 360° divided by the number of tubes, the portions of the tubes disposed in the spaced layers being substantially equidistant from each other and so spaced from the outer envelope of said material, that heat is transferred substantially uniformly between the material and the tubes in progressive layers perpendicular to said axis.

2. Apparatus in accordance with claim **1** wherein the number of layers between said beginning and an end point is equal to the number of tubes.

3. Apparatus in accordance with claim **1** wherein the number of layers between said beginning and an end point is equal to 2.

4. Apparatus in accordance with claim **1** wherein each tube of said set is bent in the form of a flat helix and extending around said axis with decreasing radius of curvature to a point near said axis, the tube then continuing in increasing radius of curvature and upward inclination, crossing itself and forming a first loop, and continuing to the plane of the adjacent layer, and then continuing in the last named plane in another flat helix of decreasing radius of curvature to a point near said axis, the tube then continuing in increasing radius of curvature and upward inclination, again crossing itself and forming a second loop axially misaligned from the first loop.

5. Apparatus in accordance with claim **4** wherein the loops of the successive layers are misaligned 360° divided by the number of tubes.

6. Apparatus in accordance with claim **4** wherein the loops of the successive layers are misaligned 180°.

References Cited

UNITED STATES PATENTS

1,382,670	6/1921	Price	165—145
2,081,043	5/1937	Kuhni	165—163
3,163,209	12/1964	Shinn	165—145

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