

Feb. 5, 1952

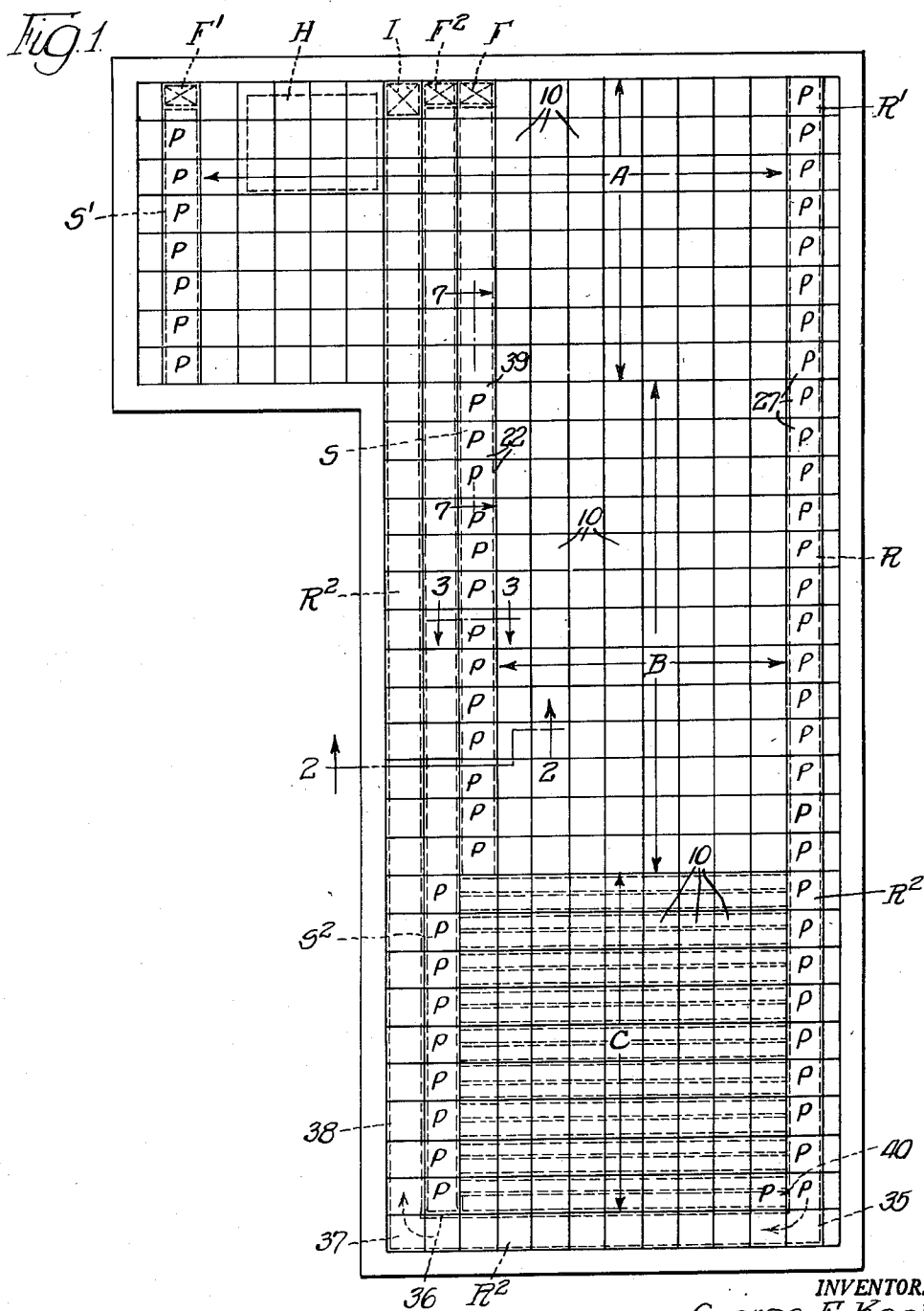
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2,584,591

RADIANT HEATING SYSTEM

Filed May 7, 1947

4 Sheets-Sheet 1



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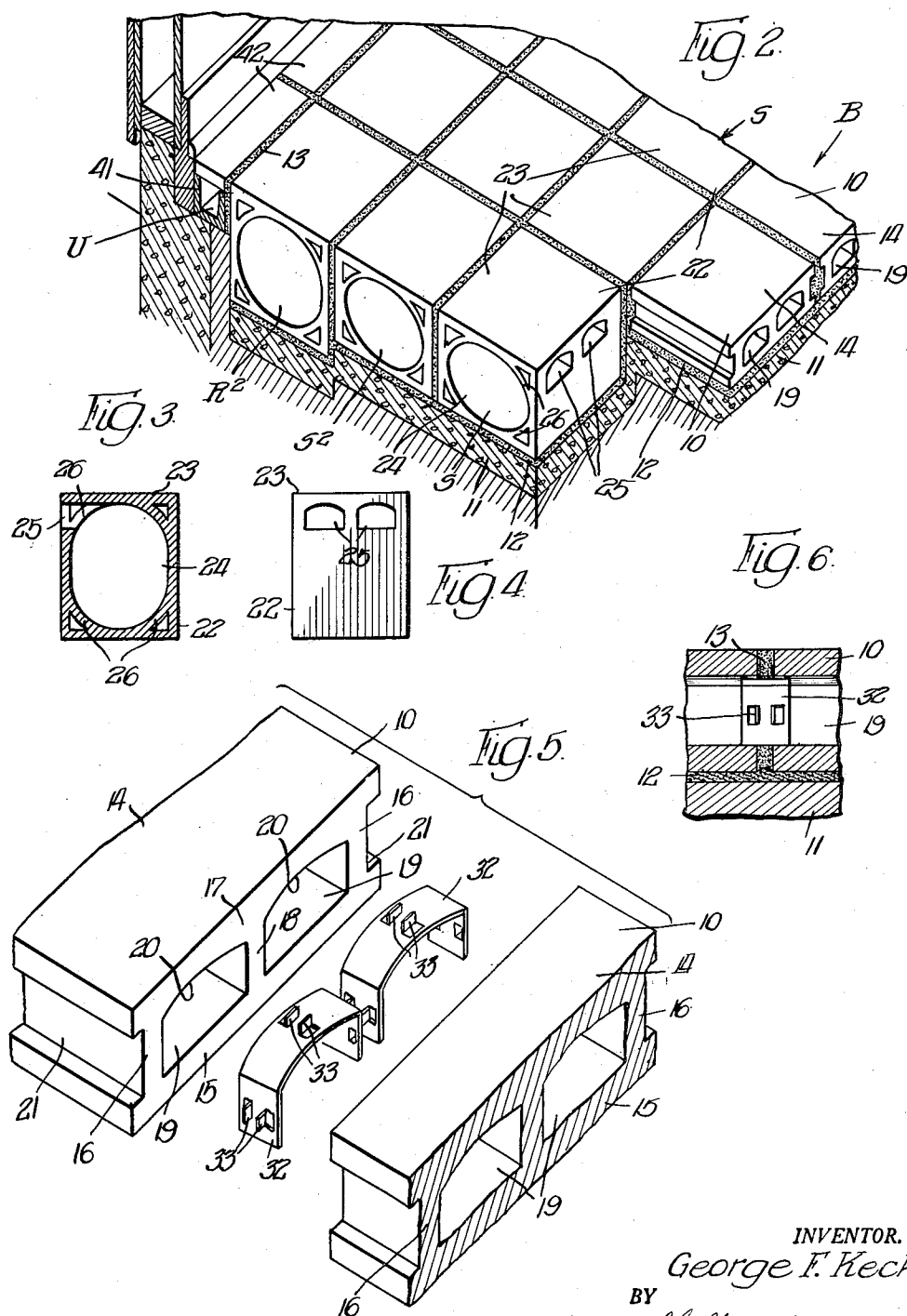
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RADIANT HEATING SYSTEM

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4 Sheets-Sheet 2



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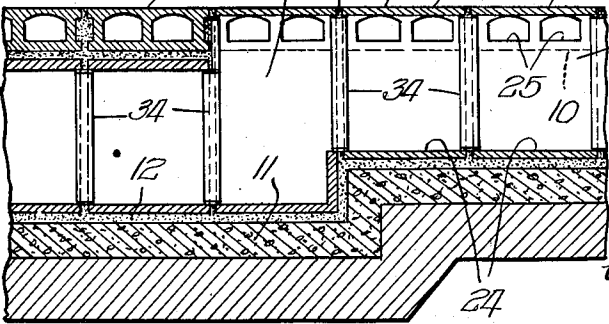
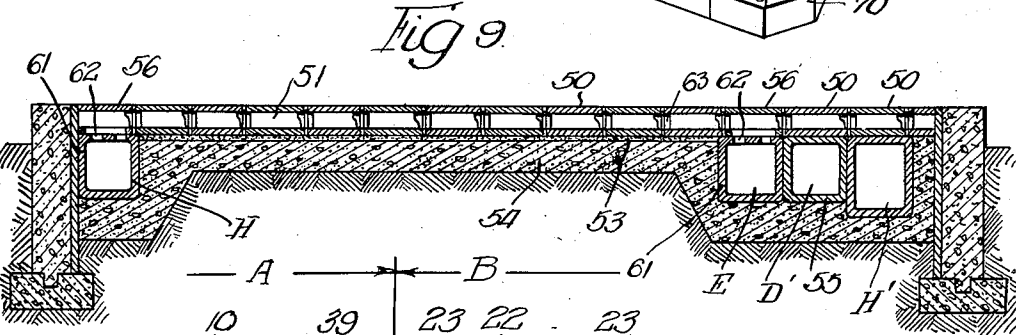
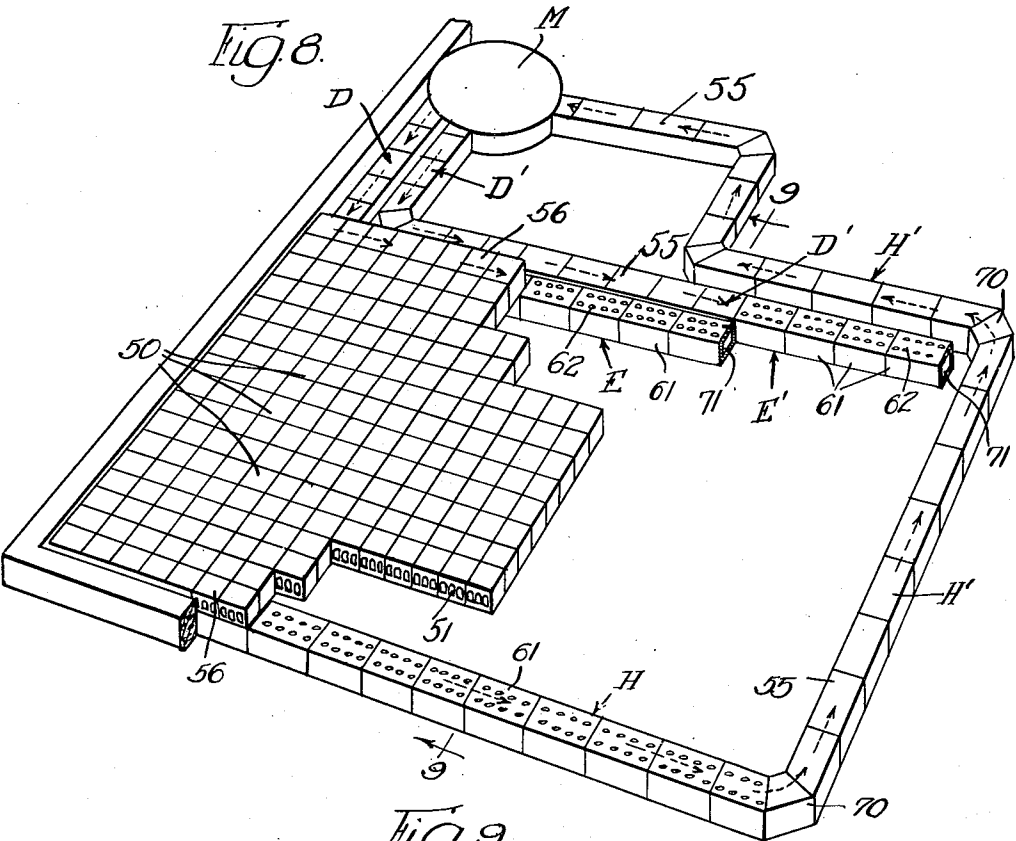
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RADIANT HEATING SYSTEM

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4 Sheets-Sheet 3



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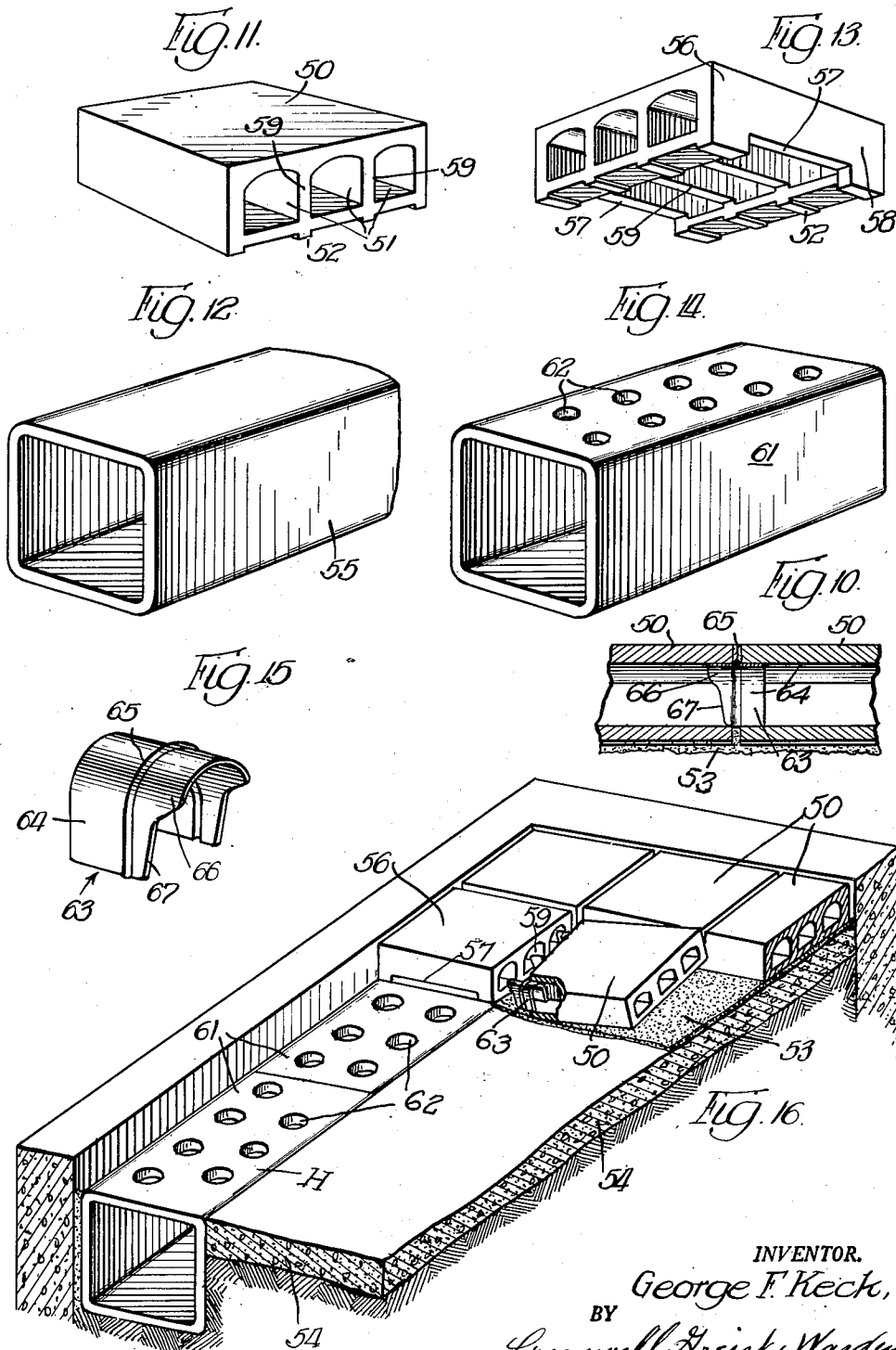
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RADIANT HEATING SYSTEM

Filed May 7, 1947

4 Sheets-Sheet 4



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## UNITED STATES PATENT OFFICE

2,584,591

## RADIANT HEATING SYSTEM

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Application May 7, 1947, Serial No. 746,601

7 Claims. (Cl. 237-69)

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The present case is a continuation-in-part of my co-pending application Serial No. 528,334, filed March 27, 1944, now Patent Number 2,422,685, directed to improvements in Radiant Heating for Buildings.

This invention has to do with radiant heating for buildings, and is particularly concerned with the construction and arrangement of the various ducts and headers employed in handling the circulation of the heated air or other fluid.

One of the principal objects of the invention is to provide, in a radiant heating system, a hollow tile floor structure through which the hot air is circulated in a novel and highly advantageous pattern.

Another important object of the invention is to provide a hollow tile floor structure in which tiles are employed which not only form the conduits for the hot air but constitute the finished load-supporting surface of the floor as well.

Still another important object is to provide tiles of special and unique design for use in a system of the character described.

Yet another object is to provide a radiant or panel heating system of the foregoing character, including novel alternative assemblies or arrangements of special tiles for the purpose of supplying heated air from a central source, for distributing the heated air from said supply means by parallel loop duct flow throughout predetermined floor areas, and for returning the heated air to the source, said arrangements permitting the laying out of a complete space heating system with the use of a minimum of different types of special tile elements.

A still further object is to provide a floor or panel heating system of the type described including an assembly of tiles and novel bridging or connecting means disposed at the tile joints and adapted to facilitate and expedite installation of the system.

Another specific object is to provide an improved tile bridging or connecting element of the type referred to in the preceding paragraph.

Yet another and more general object is to provide various novel assemblies of tiles, sub-assemblies thereof and tiles per se, adapted to provide an improved circulation of heating medium in a radiant panel heating system.

Other more specific objects and advantages will be apparent to those skilled in the art upon a full understanding of the two alternative forms of the new radiant heating layout herein illustrated, and the construction and arrangement of the several special tile units entering into the same.

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While the invention is described herein as applied particularly to heating, it is equally applicable to cooling, and the various references made herein to heating are therefore to be construed as meaning broadly a conditioning of the air or other fluid, whether such conditioning involves heating or cooling.

Preferred embodiments of the invention are presented herein by way of exemplification, but it will of course be apparent to those skilled in the art that the invention is susceptible of incorporation in various other structurally modified forms coming equally within the scope of the appended claims.

In the accompanying drawings:

Fig. 1 is a plan view of a hollow tile floor structure constructed in accordance with one embodiment of the invention;

Fig. 2 is a perspective view of a marginal portion of the floor structure shown in Fig. 1, taken approximately on the line 2-2 of Fig. 1;

Fig. 3 is a horizontal section through one of the tiles of a supply or return header of the floor structure, taken on the line 3-3 of Fig. 1;

Fig. 4 is a side view of the tile shown in Fig. 3;

Fig. 5 is a perspective view of an intermediate portion of the floor structure, showing two of the tiles separated to expose the bridge members which are inserted in the aligned ends of the ducts in the tiles when the latter are brought together;

Fig. 6 is a section through the joint between the ends of two of the field forming tiles, showing one of the bridge members in position;

Fig. 7 is a fragmentary sectional view of an intermediate portion of the floor structure, taken approximately on the line 7-7 of Fig. 1;

Fig. 8 is a diagrammatic perspective view of a layout of radiant floor heating system in accordance with an alternative, modified form of the invention;

Fig. 9 is a section taken along a line corresponding generally to line 9-9 of Fig. 8;

Fig. 10 is a fragmentary enlarged view illustrating a sub-assembly of tile elements and a modified form of bridging, connecting or joining element associated therewith in accordance with the invention;

Figs. 11 to 14 inclusive are perspective views of various tile elements of the type incorporated in the layout represented by Figs. 8 and 9;

Fig. 15 is a perspective view of the bridge or connector element appearing in Fig. 10; and

Fig. 16 is a fragmentary sectional view further illustrating certain details of the layout appearing in Figs. 8 and 9 and showing the method

of interconnecting the tile elements of the floor system in installing the latter.

The floor structure shown in the embodiment of Figs. 1 to 7 inclusive of the drawings is composed throughout practically its entire expanse of a large number of hollow flat-topped tiles 10 (see Figs. 2, 5, 6 and 7) which tiles are arranged in regular rows like ordinary floor surfacing tiles. The tiles 10 are individually supported on a rigid sub-base 11 of suitable material, and are set flush with each other on a relatively thin layer 12 of suitable bedding material. The edges of the tiles are separated slightly from each other and the spaces between such edges are filled in and pointed up with strip-like sections 13 of suitable jointing material, which material may be the same as the material used for the bedding layer 12.

Each of the tiles 10 is a vitrified clay unit of rectangular cross section which is closed at its top 14, bottom 15 and sides 16, is open at its ends 17, and is provided midway between its sides 16 with a vertical partition 18. The partition 18 reinforces the top 14 and divides the hollow interior into two open-ended passages 19 for directing the hot air used in the system. The under surface of the top 14 is arched at 20 between the sides 16 and the partition 18, whereby to afford maximum load-supporting strength with minimum thickness over the passages 19. The outer surfaces of the sides 16 are recessed at 21 between their upper and lower edges, whereby to provide keying spaces of substantial size between the opposed sides of adjacent tiles for the reception of the jointing material while still permitting the tiles to be brought fairly close together.

In applying the present system to the floor of a building in which several rooms are to be located on the same floor—as in the ordinary dwelling—the tiles 10 can be arranged advantageously in a number of separate groups, as for example the three rectangular groups included within the areas indicated respectively by the crossed arrows A, B and C in Fig. 1. Each of these groups can be individually supplied with the hot air used in heating the tiles 10, thus enabling the temperature of the floor in any particular area to be controlled easily in accordance with requirements and independently of the proximity or remoteness of such area from the source of the hot air.

Referring to the intermediate group B—the tiles 10 in that group are positioned in a number of transverse rows, with the passages 19 in the tiles in each row all extending in the same direction as the transverse rows in endwise communication with each other. The hot air used in heating the tops 14 of the tiles in group B is fed under pressure from a heater H or other suitable source up through a flue F into a supply conduit S. The conduit S extends horizontally at right angles to the rows of tiles in group B and opens laterally after the fashion of a header into each of the passages 19 in the tiles in that group.

The supply conduit S is composed of a single row of open-ended tiles 22 (see Figs. 2, 3 and 4) which have tops 23 of the same shape and size as the tiles 10. The tiles 22 are of greater depth than the tiles 10 and each contains a main passage 24 and two side openings 25. The openings 25 are of the same size as the passages 19 in the tiles 10 and are disposed in communication with the latter. The tiles 22 are provided interiorly with arcuate reinforcing portions 26 which serve to provide the requisite load-supporting strength. The tiles 22 are set in the bedding layer 12 in the same manner as the tiles 10, with their tops 23

flush with the tops 14 of the tiles 10, and with each of the tiles 22 in lateral alignment with one of the rows of the tiles 10, thus presenting a finished tile floor surface of the same regular tile pattern throughout.

After the air supplied by the conduit S to the tiles 10 in group B has traveled the lengths of the passages 19 in the tiles 10 it enters a return conduit R and flows through the same back to the air intake of furnace F.

The return conduit R, like the supply conduit S, extends horizontally at right angles to the rows of tiles in group B and is composed of a single row of open-ended tiles 27 similar to the tiles 22, having tops of the same size and shape as the tiles 10, with main passages and side openings like those shown in Figs. 3 and 4, the latter being disposed in communication with the passages 19 in the tiles 10. The tiles 27 are set into the floor in the same manner as the tiles 10, with their tops flush with the tops 14 of the tiles 10.

When setting the tiles 10 in the bedding layer 12, and before bringing the tiles in each row together, inverted channel members 32 of thin sheet metal or other suitable material are telescoped into the confronting ends of the passages 19 (see Figs. 5 and 6), whereby to render such passages continuous throughout each row of tiles and prevent entry of the jointing material into the passages. The members 32 are provided intermediate their ends with out-turned positioning tongues 33 which limit the extent of insertion of the members into the ends of the passages. Similarly functioning bridge members 34 are inserted within the ends of the passages in the rows of tiles forming the supply and return headers and also in the side openings in those tiles.

The tiles forming groups A and C are laid out in the same general way as the tiles forming group B.

The tiles 10 of group A are positioned in a number of transverse rows, with the passages 19 in the tiles in each row all extending in the same transverse direction in endwise communication with each other. The hot air used in heating the tops 14 of the tiles in group A is fed under pressure from the heater H up through a flue F<sup>1</sup> into a supply conduit S<sup>1</sup>. The conduit S<sup>1</sup> extends horizontally at right angles to the rows of tiles 10 in group A and opens laterally into each of the passages in the tiles in that group. The conduit S<sup>1</sup>, like the conduit S, is composed of a single row of the tiles 22. The hot air which is fed into the tiles 10 of group A is discharged from the same into a return conduit R<sup>1</sup>. And the conduit R<sup>1</sup>, is composed of a single row of the tiles 27 and emptying into the conduit R.

The tiles 10 of group C are similarly fed with hot air from a supply conduit S<sup>2</sup>, the hot air upon leaving the tiles 10 discharging into a return conduit R<sup>2</sup>. The return conduit R<sup>2</sup> is connected in series with the two other return conduits. It makes a right angular turn at 35 at the far end of group C; passes the closed end 36 of the supply conduit S<sup>2</sup>; makes another right angular turn at 37; and returns alongside the supply conduit S<sup>2</sup> at 38 to an intake flue I leading back into the heater H.

In various supply and return conduits those tiles of the conduits which are perforated laterally for communication with the passages 19 in the tiles 10 are marked with the letter P (see Fig. 1) in order to distinguish them from the unperforated tiles in other stretches of the conduits.

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Where the conduits  $S$ ,  $S^2$  and  $R^2$  traverse section A of the floor structure such conduits pass under the field tiles 10 of that section without interfering in any way with the circulation through such field tiles, the necessary vertical jogging being effected in each conduit through the introduction of a special conduit tile 39 (see Fig. 7) having a vertical dimension equal to the combined vertical dimensions of the tiles 10 and 22.

Where the conduit  $R^2$  makes the right angular turn at 35 a special conduit tile 40 containing an L-shaped air passage, as illustrated in my copending application identified above, may be positioned in the reentrant angle to prevent any diminishment in the flow through the conduit in turning the corner.

The usual utilities—such as pipes and wires—may be advantageously placed in one or more marginal conduits U (see Fig. 2) formed between upwardly opening channel members 41 and flat cover tiles 42 arranged flush with the upper surface of the floor structure. The tiles 42, which can be removed without difficulty at any point to give access to the utilities, can be jointed in line with the joints between the various other tiles whereby to present if desired an uninterrupted tile pattern over the entire floor area.

Figs. 8 through 16 illustrate a further highly desirable and alternative layout of a floor heating system in accordance with the invention and the various component tile and connector elements involved in that layout. Said components, which are preferably of a vitrified clay material, are illustrated individually in Figs. 11 through 15, to which attention is directed.

Referring to Fig. 11, the block-like surfacing and distributing or field tile 50 shown therein is generally similar to the tile 10 of the earlier embodiment, although it is divided into three parallel heat distributing passages 51, instead of two, and is provided along its bottom with the longitudinally extending rib 52 adapted to be embedded in and to interlock with cementitious grout or other suitable bedding material 53 in which the tiles are supported on a sub-base 54, as illustrated in Figs. 10 and 16. The passages or ducts 51 extend from end to end through the tile, which is otherwise imperforate. Its upper surface serves as a finish and load-supporting surface, in the same manner as contemplated in the first embodiment of the invention described above. The passages are arched for strength, as illustrated in Fig. 11.

Fig. 12 illustrates a fragment of a standard, elongated and hollow, single conduit tile, designated by the reference numeral 55. This conduit is generally rectangular in shape and is employed with like conduits, all disposed beneath the level of the field tiles 50, in supplying hot air from the furnace manifold or other heat source M shown in Fig. 8, and for returning the cooler air thereto after circulation through the field of the system. A special floor surfacing and feed and return manifold tile 56 is illustrated in Fig. 13, which is somewhat similar to the field tile 50. Its exposed upper surface is identical in shape and area to that of tile 50, with the further feature that the bottom thereof is medially and transversely recessed or cut away to provide distributing recesses 57 in the opposite side walls 58 of said tile and in the parallel intermediate partitions 59, thereby placing the three tile passages in communication at said recesses.

In accordance with the invention a series of

the manifold tiles 56 are associated with the special header or distributor tiles 61 shown in Fig. 14, in the manner illustrated in Figs. 8, 9 and 16. Said tile 61 is an elongated single conduit type element, generally similar to the conduit tile 55 of Fig. 12, with the additional feature of a plurality of laterally and longitudinally spaced air supply (or return) openings 62 in its upper surface, which are formed in rows, or in any other desired arrangement.

Inasmuch as the manifold tile 56 receives heated air from a number of relatively large sized openings 62 in header tile 61, as shown in Fig. 16, it follows that its transversely extending bottom recess should be of substantially greater width than any of its longitudinal passages, in order to avoid an objectionable back pressure.

Fig. 15 illustrates details of a special sheet metal bridging element or shield adapted for the same purpose as the members 32, 34 of the first modification, but formed in a somewhat different fashion. Said shield elements are generally designated by the reference numeral 63, being stamped and shaped in an inverted U outline from a flexible steel sheet. The form of the element 63 is such as to provide a main body portion 64 of substantial length, and externally projecting, transverse, continuous locating bead 65 formed in the element adjoining said body portion, and a forwardly projecting guide tongue 66 which is cut away rearwardly at 67 adjacent the lower ends thereof for a purpose to be described.

In so far as it concerns the general principles of circulation of hot air in a loop duct system, in accordance with the invention, the layout illustrated in Figs. 8, 9 and 16 corresponds closely to that shown in Figs. 1, 2 and 7 of the drawing. It differs therefrom in the types of special tiles employed and the method of arrangement of the component tiles, in the manner now described.

Referring to Fig. 8, which represents a standard and relatively simple installation contemplated by the invention, a number of the plain vitrified tile supply conduits 55 are associated end to end, employing a suitable cementitious bonding material at the joints in a well known manner, and preferably laying said tile on insulating material supported by sub-base 54, to provide a plurality of outgoing supply ducts D, D<sup>1</sup> which are connected at their intake end with the manifold heat source M. The number of these supply ducts may obviously be varied in accordance with the number of rooms or areas to be heated. These ducts are arranged to extend in parallel side-by-side relation along one direction of the area involved and, as illustrated in Fig. 9, are insulatively supported on the sub-base 54 in substantially spaced relation beneath the intended floor surface.

It is to be understood that the ducts D, D<sup>1</sup> are constituted by the imperforate tile members 55 and serve merely as supply conduits which, after an appropriate run, depending on the lengths of the respective field areas serviced thereby, empty into an aligned series of the perforated header or distributing tiles 61, arranged in end-to-end communication in the fashion illustrated in Fig. 8. The tiles 61 are of course laid on the same level as ducts D, D<sup>1</sup> and are joined to one another at their ends, using bridge members similar to the members 32, 34 or 63, to constitute continuous header or distributor ducts E, E<sup>1</sup> in end communication with the respective supply ducts D, D<sup>1</sup>. Each line of distributor tiles 61, constituting the respective ducts E, E<sup>1</sup> serve to

supply hot air to its corresponding section of the floor surface in the identical fashion served by the supply conduits S, S<sup>1</sup>, S<sup>2</sup>, of the first form of the invention described above.

Heated gaseous medium discharged into the respective distributor ducts E, E<sup>1</sup> is vented upwardly through the opening 62 in the constituent tiles thereof and passes through the recessed bottom and into the interior of the aligned series of manifold tiles 56 immediately thereabove, in the manner illustrated in Figs. 9 and 16. The recesses 57 in the walls and partitions of said manifold tiles serve to distribute and equalize the discharge of gas passing thereto from respective adjacent tiles 61 of header ducts E, E<sup>1</sup>. The manifold tiles 56 are laid coplanar with the floor surfacing tiles and, like said last named tiles, constitute a continuous floor surfacing area on the margins of the field area. Heating medium travels from the tiles 56 through the respective aligned passages 51 of the parallel rows of field tiles 50 and across the respective areas serviced by the respective headers E, E<sup>1</sup>, in a manner which will be apparent, discharging from the tiles 50 into discharge manifold tiles which are identical with the tiles 56, though being arranged over the continuous receiving and return header H, as shown in Fig. 8. The header H is constituted by aligned perforated tiles 61 and receives the discharge from all tile units of the area serviced by the supply ducts D, D<sup>1</sup> and headers E, E<sup>1</sup>. It empties into the continuous, imperforate return duct H<sup>1</sup>, through which it is circulated in the direction illustrated by the arrows in Fig. 8 to a manifold of the heat source.

As illustrated in Fig. 8, special corner tile 70 may be employed at the end of the section at the corners of the respective supply and return ducts or headers. Likewise, it will be appreciated that the end tile of the header ducts E, E<sup>1</sup> is suitably closed by a plate, or plug or like provision 71.

Ducts H, H<sup>1</sup> are laid with their tops flush with the tops of the respective ducts D, D<sup>1</sup> and E, E<sup>1</sup> as shown in Fig. 9, the tops of the floor surfacing and distributing tiles 50, 56 disposed thereabove also being mutually coplanar as shown.

Further extended discussion of the arrangement and advantages of the system illustrated in Figs. 8, 9 and 16 appears unnecessary, in view of the description set forth in connection with layout of Fig. 1. The modification of Figs. 8 to 16 has all the advantages of the earlier modification and, moreover, represents a considerably greater standardization of the tile elements which go to make up the same. Furthermore, the method of laying the tile is simplified and the installation expedited generally.

With reference to the shield or connector 63 illustrated in Fig. 15, the novel outline thereof contributes substantially to increased ease and speed in laying the system. As illustrated in Fig. 10, this element 63 is disposed in telescoped and connecting relation to two adjacent tiles 50, 56, the bead 65 positioning the shield relative to the tile and also locating the tiles relative to one another. Naturally, the element is associated similarly with two adjacent tiles 50. In employing this shield it is first inserted fully into the tile being laid, in the manner shown in Fig. 16, and the forwardly projecting, overhanging lip 66 is then inserted into the tile 56 or 50. The relieving at 67 of the legs of the forward guide tongue 66 of the shield considerably facilitates use of the device, since it enables swinging insertion thereof into a previously laid tile,

rather than by a purely horizontal, sliding or translational movement in the grout 53. The tile in which the shield is inserted may be tipped upwardly, as shown in Fig. 16, the lip initially inserted and the tile and connector swung downwardly and forwardly toward and into the adjacent tile in a very simple and expeditious manner. Fig. 16 indicates the gas return section of an installation; however, it is to be understood that the same relationship of tiles 50, 56 and 61, which is shown to best advantage in that figure, exists at the supply or outgoing section.

The duct H<sup>1</sup> through which the air is returned to the source is preferably of somewhat larger cross-sectional area than the individual supply ducts, inasmuch as it handles the entire volume of air circulating in the system.

It is evident that any given area of a building serviced by any of the ducts D, D<sup>1</sup> of the system may be heated to any degree desired by merely dampering said supply ducts, without in any way sacrificing the uniformity of heating at any point in said area. This is an important advantage of the multiple loop duct arrangement, whether as shown in Fig. 8 or in Fig. 1. In both forms the tiles constitute the exposed load and wearing surface, the outstanding difference being that the supply and return conduit means of the Fig. 8 layout are positioned lower than the field and manifold tiles, involving an improved and simplified method of supplying and exhausting the latter.

I claim:

1. A panel heating system comprising a plurality of parallel heating and surfacing units extending across an area to be heated and provided with internal communicating passages, and means for the circulation of fluid heating medium through said passages, comprising a hollow header duct disposed at a level beneath said units and apertured for the flow of heating medium, and a row of hollow manifold tiles disposed over said duct, said last named tiles having an upper surface substantially flush with the upper surface of said surfacing units and being provided with end openings communicating the interior of the tiles with the internal passages of said surfacing units, said manifold tiles having means for the communication of the tile interior with the interior of said header duct through said duct aperturing, whereby to connect said first named units and duct for the circulation of said heating medium.

2. A panel heating system comprising a plurality of parallel heating and surfacing units extending across an area to be heated and provided with internal communicating passages, and means for the circulation of fluid heating medium through said passages, comprising a hollow header duct disposed at a level beneath said units and apertured on an upper surface thereof for the flow of heating medium, and a row of hollow manifold tiles disposed over and resting on said duct, said last named tiles having an upper surface substantially flush with the upper surface of said surfacing units and being provided with end openings communicating the interior of the tiles with the internal passages of said surfacing units, said manifold tiles having an opening the surface thereof adjoining said duct for the communication of the tile interior with the interior of said header duct through said duct aperturing, whereby to connect said first named units and duct for the circulation of said heating medium.

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3. A panel heating and circulatory system comprising a plurality of parallel adjacent rows of aligned field tiles defining a floor surface, the tiles of said rows extending across an area to be heated and being provided with aligned, internal communicating passages, and means for the circulation of fluid heating medium through said passages, comprising a hollow header duct disposed at a level beneath said tiles and provided with openings in an upper surface thereof for the distribution of heating medium, and a transversely extending row of hollow manifold tiles resting on said header duct, said last named tiles having an upper surface substantially flush with the upper surface of said field tiles and being provided with lateral openings communicating the interiors thereof with the internal passages of said field tiles, said manifold tiles having an opening on a lower surface thereof adjoining said duct in communication with said duct aperturing whereby to connect said field tiles and duct for the circulation of said heating medium.

4. A panel heating and circulatory system comprising a plurality of parallel adjacent rows of aligned field tiles defining a floor surface, the tiles of said rows extending across an area to be heated and being provided with aligned, internal communicating passages, and means for the circulation of fluid heating medium through said passages, comprising a hollow header duct disposed at a level beneath said tiles and provided with openings in an upper surface thereof for the distribution of heating medium, and a transversely extending row of hollow manifold tiles resting on said header duct, said last named tiles having an upper surface substantially flush with the upper surface of said field tiles and being provided with lateral openings communicating the interiors thereof with the internal passages of said field tiles, said manifold tiles having an opening on a lower surface thereof adjoining said duct in communication with said duct aperturing whereby to connect said field tiles and duct for the circulation of said heating medium, said manifold tiles being recessed on the sides thereof to communicate the interiors of adjacent tiles of said row with one another.

5. In combination, a header duct adapted to circulate a fluid medium, said duct being apertured on the upper surface thereof, and a series of hollow manifold tiles arranged in a row along

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said duct and supported thereby, said tiles each having a recess on the lower portion thereof for internal communication with said duct through said aperturing, and being provided with a lateral opening for the flow of said medium.

6. In combination, a header duct adapted to circulate a fluid medium, said duct being apertured on the upper surface thereof, a series of hollow manifold tiles arranged in a row along said duct and supported thereby, said tiles each having a recess on the lower portion thereof for internal communication with said duct through said aperturing, and being provided with a lateral opening for the flow of said medium, and a plurality of rows of floor surfacing tiles provided with aligned internal passages in communication with the openings in said respective manifold tiles.

7. In combination, a header duct adapted to circulate a fluid medium, said duct having a plurality of fluid flow openings on the upper surface thereof, and a series of hollow manifold tiles arranged in a row along said distributor duct and supported thereby in covering relation thereto, said tiles having a lower portion thereof recessed for communication of their respective interiors with the interior of said duct through the openings in the latter, and being provided with lateral openings in the sides thereof for flow of said medium in a direction at an angle to said row.

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