COLUMN ARRANGEMENT FOR MULTISTORY STRUCTURES

Filed June 9, 1969 2 Sheets-Sheet 1

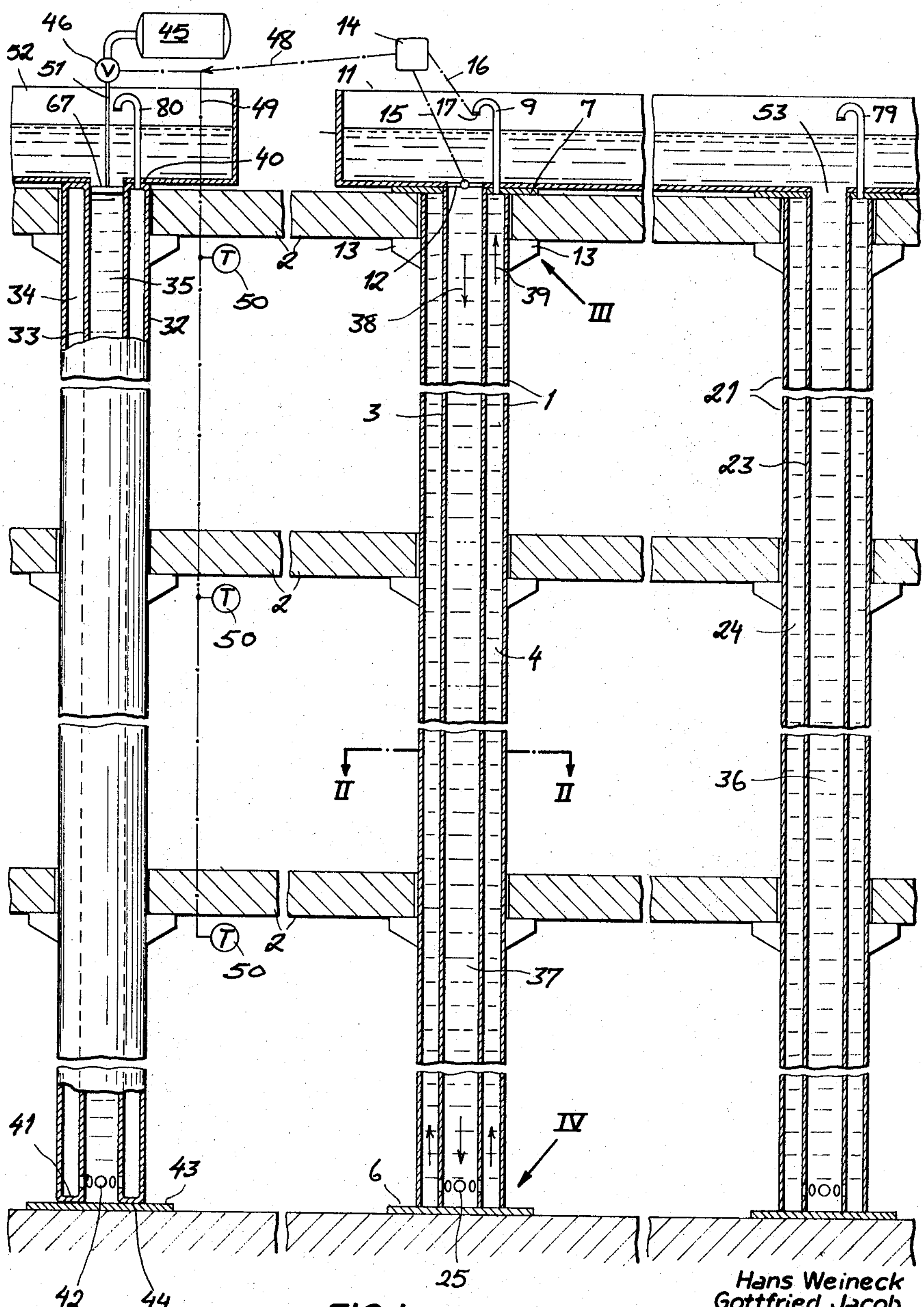

FIG. 1

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COLUMN ARRANGEMENT FOR MULTISTORY STRUCTURES

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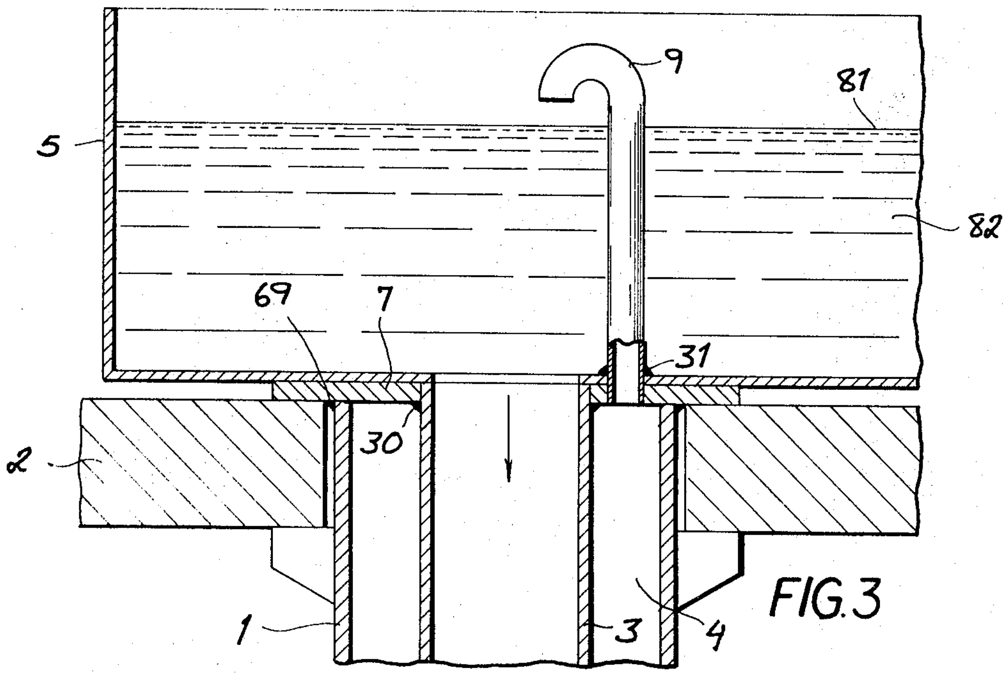

FIG. 3

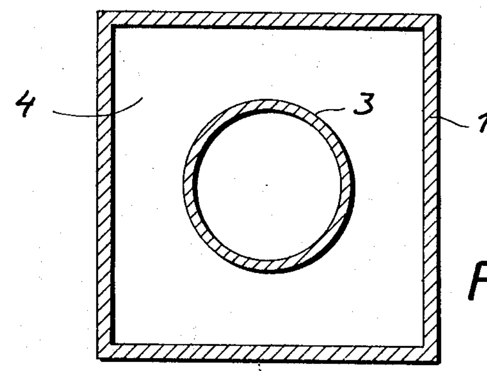

FIG. 2

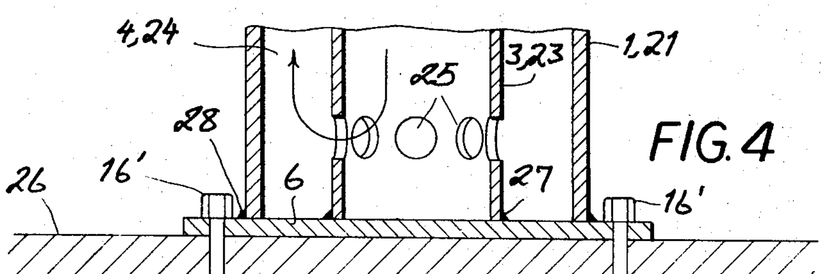

FIG. 4

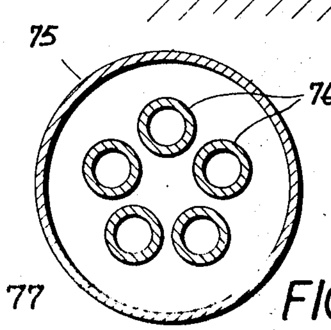

FIG. 5

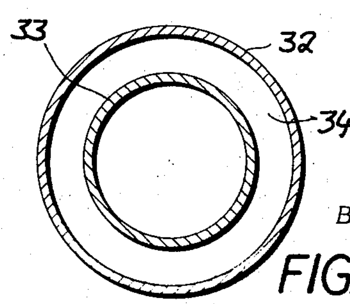

FIG. 6

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COLUMN ARRANGEMENT FOR MULTISTORY STRUCTURES

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Int. Cl. E04b *1/92, 1/74*
U.S. Cl. 52—168 6 Claims

ABSTRACT OF THE DISCLOSURE

A steel-column arrangement for multistory steel structures in which the column is hollow and a coaxial inner duct is provided for introducing water permanently or upon the development of fire into the chamber surrounding the inner duct and enclosed by the outer column. An equalizing receptacle at the top of the column communicates with the inner duct which connects with the surrounding circumferential space at its bottom. A standpipe opening above the water level in the container is provided at the top of this outer space to vent vapor therefrom.

Our present invention relates to multistory steel structures using hollow steel columns and, more particularly, to a system for protecting such structures against fire.

It has been proposed heretofore to protect steel structures using columns and especially tubular or hollow columns, by providing means for limiting the transmission of heat among the column for a selected time sufficient to allow firefighters to reach the scene or otherwise begin firefighting operations.

Such protective measures are particularly desirable because the steel columns extending through several stories or tiers of the structure have the high-thermal conductivity necessary to transmit heat at combustion temperatures or above from the site of a fire to a locale free from combustion in short order. To this end, steel columns and supports of this character have been provided with thermal insulation around the post or column. While such insulation often serves to prevent penetration of heat at combustion temperatures to the steel of the column in less than the desired period and delays the spread of fire, the insulating systems have the disadvantage that they are both uneconomical and architecturally unaesthetic.

It has also been proposed, at least partly as a result of the disadvantages of the insulated systems, to provide means for filling the tubular steel column with a heat-dissipating medium such as cooling water or steam. The columns may be charged with cooling fluid through a supply duct externally of the structural elements, this system having aesthetic disadvantages and functional drawbacks which have led to the disuse of these systems. An important drawback of such arrangements is the possibility that the fire may heat strongly the supply duct, thereby limiting the filling of the structural steel columns and posts with the coolant or otherwise rendering the arrangement ineffective to prevent the transmission of heat at high temperatures along the steel columns.

It is, therefore, the principal object of the present invention to provide an improved steel-column construction in which the foregoing disadvantages are obviated and in which improved heat dissipation is effected in order to limit the transmission of high temperatures along such columns.

Another object of this invention is to provide a system for preventing the spread of fire in a column structure of the general character described.

Yet another object of our present invention is the provision of an improved column structure which is both economical and capable of providing efficient heat dissipation in the event of fire and the like.

These objects and others which will become apparent hereinafter are attained, in accordance with the present invention, with a column arrangement for multistory steel structures in which the columns provide support for the load-bearing elements, i.e., beams, trusses or slab-type flooring, wherein a hollow column is provided internally with a fall or descent duct or pipe through which water or other cooling fluid can be fed to the interior of the hollow column.

Consequently, the column structure of the present invention comprises the outer hollow load-supporting column and, substantially coaxial therewith and surrounded thereby with all-around clearance, a central liquid-supply pipe, conduit or duct communicating at its top with a source of water, and, indeed, serving at least in part as a reservoir for the coolant. The inner pipe communicates with the surrounding space, provided between the inner duct and the outer column, at the bottom of the column and the duct so that convection currents induced by heat (e.g. as a consequence of fire at one or more locations along the column) perform thermal-pumping action inducing liquid flow downwardly to the inner duct and upwardly between the inner duct and the outer column. The inner-duct means, according to this invention, while preferably a single conduit located centrally of the column and along its axes, may also be constituted by an array of inner ducts, each of which is surrounded with all-around clearance by the outer column, the inner ducts being, in turn, spaced from one another.

The inner duct may be of proportionately large dimensions, i.e. with a cross-section of area equal to, say, upwardly of 1/5 of that of the hollow column and constituting a greater proportion of the surrounding space, while extending the full height of the column to form a reservoir capable of storing substantial quantities of the cooling liquid.

At the upper end of the column, according to a specific feature of this invention, a level and pressure equalizing and expansion reservoir is provided. This reservoir, which communicates below the water level therein with its central or inner supply duct, may also be provided with one or more standpipes connecting the space above the water in the reservoir with the outer chamber between the inner duct and the column.

Another feature of this invention provides, in a column construction of the character described, means rigidly connecting the inner duct with the outer column, at least at the upper and lower end of the structure, so that the inner duct statically contributes to the load-supporting capabilities of the column. An arrangement of the latter type has the important disadvantage that the effective load-carrying cross-section of the column is increased and its rigidity augmented while anti-fire protection is provided without architecturally unaesthetic arrangements.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a vertical cross-section of a multistory column or steel structure, partly in diagrammatic form, embodying the present invention;

FIG. 2 is a cross-sectional view taken along the line II—II of FIG. 1;

FIG. 3 is a detail cross-sectional view, drawn to a slightly enlarged scale, illustrating the region III of FIG. 1;

FIG. 4 is a detail view, drawn to the same scale as FIG. 3 but illustrating the region IV of FIG. 1;

FIG. 5 is a cross-sectional view similar to FIG. 2 illustrating a different embodiment of the invention; and

FIG. 6 is a view similar to FIG. 5 of still another embodiment.

As is best seen from FIG. 1 of the drawing, a building structrue using steel-column arrangements in accordance with the present invention comprises a plurality of horizontally spaced vertical columns **1, 21, 32** extending the full height of the structure through a number of tiers or stories, three of which are represented at **2** in FIG. 1.

Members **2** represent slab-type floor structures, cross beams or the like and are held upon laterally extending brackets **13** welded to the outer srufaces of the columns **1, 21** and **32.**

The tubular steel columns **1, 21** and **32** are provided with anti-fire protection cooling systems as generally described above and including a centrally extending coolant supply duct represented at **3, 23** and **33** in this figure. Each of the ducts is coaxial with the respective column **1, 21** and **32** and is spaced from the inner wall thereof by a circumferential chamber **4, 24, 34,** extending the full height of the column.

At the bottom of each inner duct **3, 23, 33,** there are provided openings as represented at **25** and **42** communicating between the interior **35, 26, 37** of the inner duct and the surrounding cooling chamber **4, 24, 34.**

The inner ducts **3, 23** and **33** are cylindrical whereas the outer columns **1** and **21** are of square rectangular cross-section as illustrated in FIG. 2, column **32** being cylindrical.

At the lower end of the columns **1** and **21** (see FIG. 4), the outer spaces **4, 24** are closed by foot plates **6** bolted at **16′** to the foundation **26.** The columns **1, 21** are circumferentially welded at **28** to the foot plates **6** while the inner ducts, **3, 23** are circumferentially welded to these plates at **27.** Consequently, the development of a hot spot along the column, indicative of a fire, results in a convection flow of water downwardly through the inner chamber **36, 37** as represented by the arrows **38** and then outwardly through the apertures **25** at the base of each inner duct (FIG. 4) and upwardly through the outer chambers **4, 24** as represented by the arrows **39.**

At the upper end of each column, a head plate **7** is provided and is of annular construction so as to be weldable to the inner duct **3, 23** along its inner periphery **30** and at **69** to the outer column **1, 21.**

To release steam from the outer chamber **4, 24,** a standpipe **9** is mounted in the plate **7** and is welded to the latter at **31** while reaching upwardly above the level of liquid in the equalization and vapor-expansion reservoir **5,** the standpipe **9** terminating in its upper end in a downwardly turned bend. The development of steam or water vapor, as a consequence of strong heating of the column, results in a displacement of the coolant liquid upwardly through the standpipes **9** and into the reservoir **5.** The later is formed as a swimming pool atop the roof **10** of the structure and valves **12** may be provided between the inner ducts **3, 23** and the reservoir **5** to prevent flow of liquid downwardly into these ducts in the absence of a fire. Upon the development of a fire, a pressure flap **17** at the mouth of one of the standpipes is deflectable by the developed steam and operates a switch **14** controls the valve **12** to open the latter in the emergency.

The pressure-responsive switch **14** is coupled with the vapor-generation sensor **17** by a mechanical or electrical connection represented at **16** and controls, in turn, the valve **12** and another valve (not shown) at the junction of the central duct **3** with the tank **5** as represented at **15.** The upper portion **11** of the tank **5** is open as represented at **11** to allow the tank to be used as a swimming pool on the roof of the structure. Thus the tank **5** is generally flat and can extend over a substantial portion of the roof **10.**

At the left-hand side of FIG. 1, we have shown a modification of the column structure in which the inner duct **33** is built integrally into the outer duct **32** and both ducts have cylindrical cross sections as shown in FIG. 6. Instead of the foot and head plates **6** and **7** connecting the inner and outer tubes, as described in connection with columns **1** and **2,** the ends of tubes **32** and **33** are joined by bights **40** and **41.** In this embodiment as well, the inner tube **33** forms a reservoir **35** for a column of water which may enter the outer chamber **34** through the openings **42.** The inner chamber **35** is closed at its bottom end by a foot plate **43** welded to the column assembly at **44** and at its top end by a plate **67** communicating via a line **51** with a valve **46** of a pressure source **45,** such as a compressed-air tank. As represented by line **48,** the valve **46** may be opened by the sensor switch **14** upon the detection of steam at one of the standpipes **9, 79, 80** or, as represented by line **49,** by detectors **50** located at each floor of the structure and responsive to the development of unusual heat conditions indicative of fire. In this arrangement, the water is only maintained in the interior **35** of the inner duct **33** and the equalization vessel **52,** into which the standpipe **80** opens, constitutes a receptacle for overflowing water. The water is held within the central duct **33** by atmospheric pressure in the outer chamber **34** until valve **46** opens, whereupon the pressure of source **45** drives the water column from the interior of duct **33** downwardly and outwardly into the outer chamber **44** in which the water performs its cooling function.

As noted in connection with FIG. 3, the standpipe **9** etc. open above the level **81** of water **82** in the tank **5** so that steam rising in the outer chamber **4,** etc. will pass upwardly by thermal-siphon action and be expelled above the water bath **82.** Any water entrained with the rising steam or constituting the convection circulation will flow downwardly from the tank **5** through the inner duct **3** and then pass upwardly through the outer chamber **4,** thence into the standpipe, and from the latter into the tank **5.** The tank **5** is hydrostatically connected to duct **3** at the duct upper end only.

From the drawing, it is clear that the header or supply duct **3, 23, 33** extends coaxially within the hollow column **1, 21, 32** and is centrally disposed therein and is of cylindrical configuration. The inner duct can, of course, have some other configuration and can be built into the column such as its geometry corresponds in cross section to that of the column (see FIG. 6), while the annular chamber is maintained all around the central duct. In such cases, the supply duct **3** contributes to the static strength of the column and also serves as a reservoir for the cooling liquid. In general when the inner duct forms a reservoir, the corresponding tank may be of reduced volume.

In FIG. 5, we have shown a modified system wherein the outer column **75** surrounds a multiplicity of angularly equispaced parallel supply pipes **76** communicating with the space **77** around this bundle of pipes at the bottom of the column and connected to a liquid reservoir on the roof of the structure as previously described.

The improvement described and illustrated is believed to admit of many modifications within the ability of persons skilled in the art, all such modifications being considered within the spirit and scope of the invention except as limited by the appended claims.

We claim:

1. A support-column construction for a multiple story steel structure, comprising:

an upright tubular column extending over a substantial portion of the height of said structure;

a coolant-supply duct extending generally axially and centrally within said column and defining therewith an annular clearance all around said duct and running over substantially the full length of said column and said duct, said duct communicating with said clearance at the lower end thereof for feeding a liquid coolant thereto;

means rigidly connecting said duct with said column at the upper and lower ends thereof to form from the combination of said duct and said column a load-supporting member of greater load-carrying capacity than that of said column alone;

an equalizing tank for said cooling liquid hydrostatically communicating with said duct only at the upper end of said column and hydrostatically independent of the clearance at said upper end; and

a vapor-venting pipe communicating with said clearance at the upper end of said column and opening into said equalizing tank.

2. The construction defined in claim **1** wherein said duct and said column have geometrically similar cross sections.

3. The construction defined in claim **1** wherein said duct has a circular cross section and said column has a rectangular cross section.

4. The construction defined in claim **1** wherein said duct forms a water reservoir, said construction further comprising a source of pressure connected with said duct and operable to drive the water from said reservoir into said clearance.

5. The construction defined in claim **1**, further comprising means along the exterior of said column for supporting cross members of said structure at a number of stories, said duct and said column being axially coextensive and extending the full height of said structure to substantially the roof thereof, said duct being provided at the bottom of said duct with a plurality of openings com-

municating between the interior of said duct and said clearance, and said tank being generally flat and provided on the roof of said structure communicating with said duct at the upper end thereof.

6. The construction defined in claim **9**, further comprising a foot plate at the bottom of said column and peripherally welded thereto and to said duct for closing said clearance and the interior of said duct at said lower end, and a head plate peripherally welded to said column and said duct at said upper end for closing said clearance, said pipe being anchored in said head plate.

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