United States Patent [19]

Marangoni et al.

[11] **3,736,909**

[45] **June 5, 1973**

[54] RODDING DEVICE

[75] Inventors: **Elvino Marangoni,** Martinez; **Douglass G. Webb, Jr.,** Walnut Creek, both of Calif.

[73] Assignee: **Shell Oil Company,** Houston, Tex.

[22] Filed: **Sept. 27, 1971**

[21] Appl. No.: **184,138**

[52] **U.S. Cl.** **122/390,** 15/105.16, 239/187

[51] **Int. Cl.** **F23j 3/00**

[58] **Field of Search**.....15/105.16, 317; 122/390, 391; 239/187

[56] **References Cited**

UNITED STATES PATENTS

3,269,659	8/1966	Shelton et al.	15/104.16
3,184,774	5/1965	Burch	15/317
3,448,477	6/1969	Ricordeau et al.	15/317
3,450,104	6/1969	Aldrich et al.	122/391

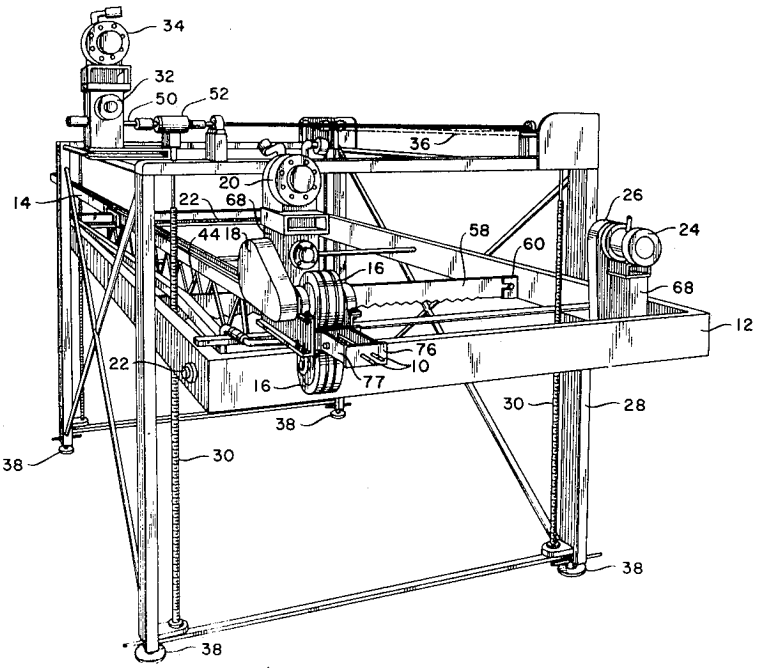
Primary Examiner—Kenneth W. Sprague

Attorney—John M. Duncan and Glen R. Grunewald

[57] **ABSTRACT**

An apparatus for cleaning the interior surface of tubes in a bank of tubes such as heat exchanger or furnace tubes, which includes a frame carrying a vertically adjustable carriage, the carriage provided with a horizontally adjustable means for supporting a fluid-carrying rod and a motor driven means for inserting and retracting the rod into the tubes, the motor driven means being positioned closely adjacent to a vertical boundary of the carriage to enable it to force the rod into a tube without buckling of the rod, and the process for employing the rodding device.

10 Claims, 7 Drawing Figures



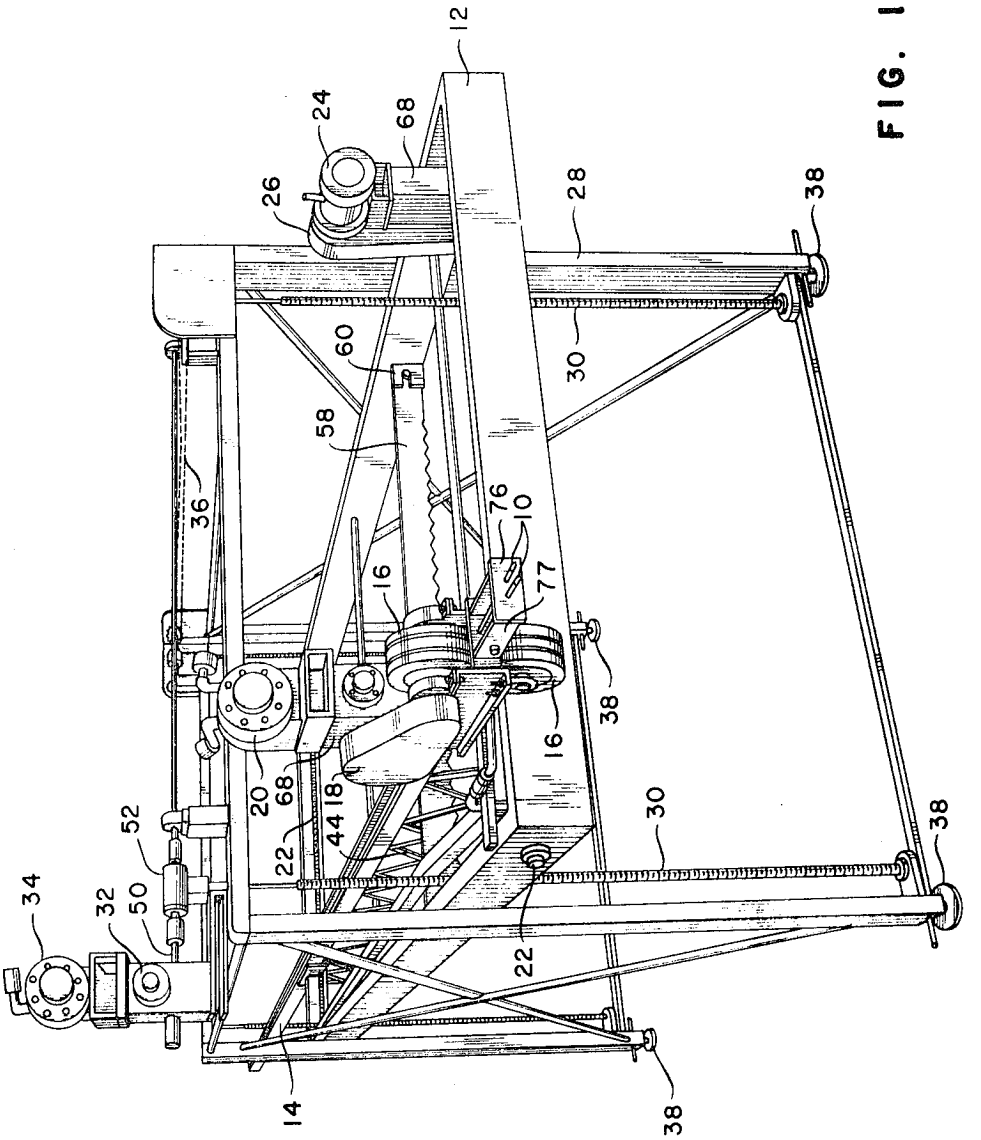


FIG. 1

INVENTORS:
ELVINO MARANGONI
DOUGLASS G. WEBB, JR.
BY: John M. Duncan
THEIR ATTORNEY

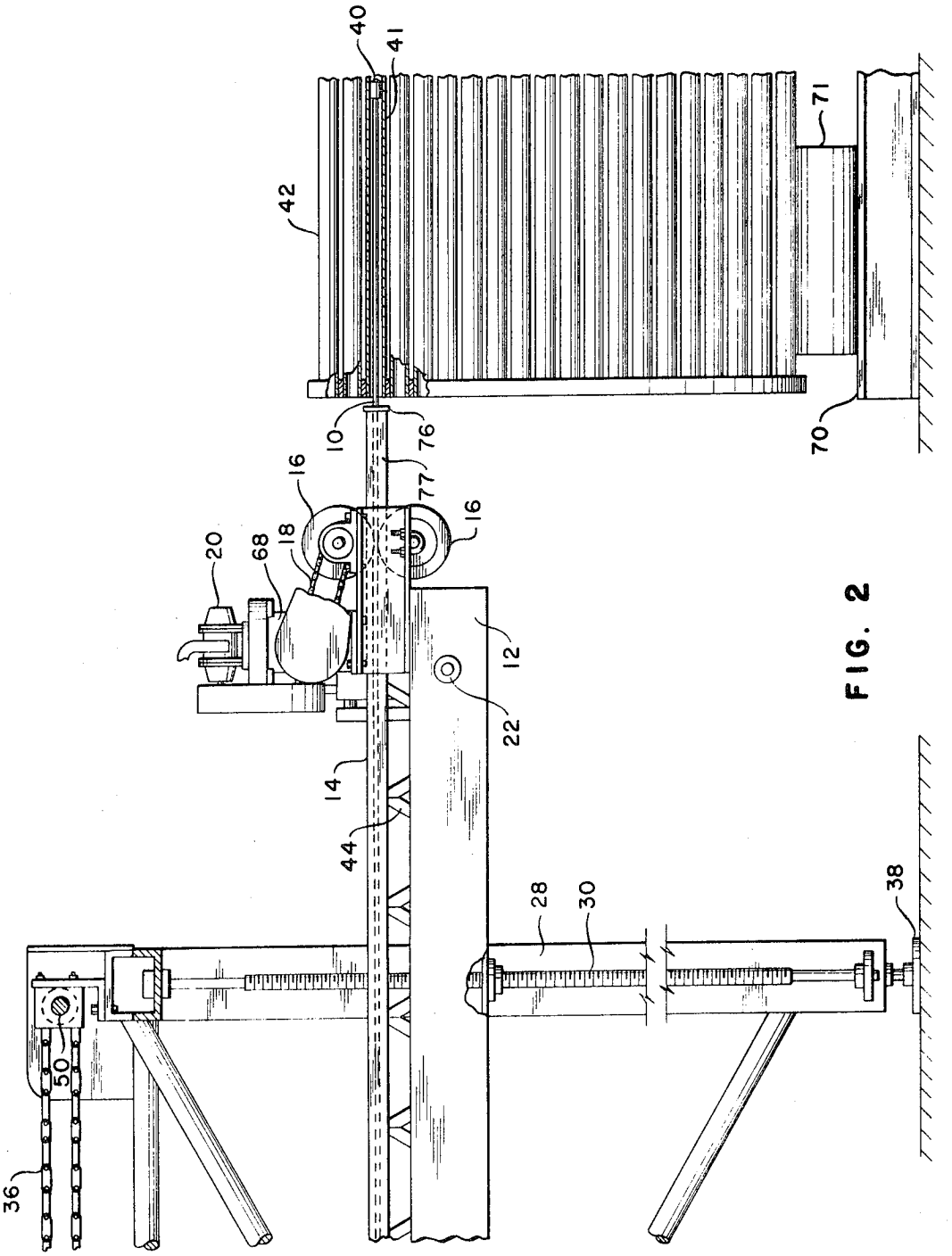


FIG. 2

INVENTORS:
ELVINO MARANGONI
DOUGLASS G. WEBB, JR.
BY: John M. Duncan
THEIR ATTORNEY

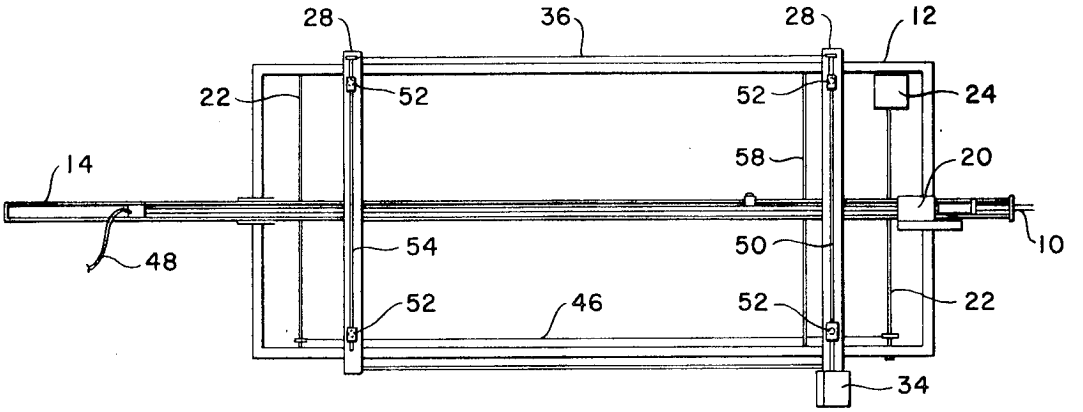


FIG. 3

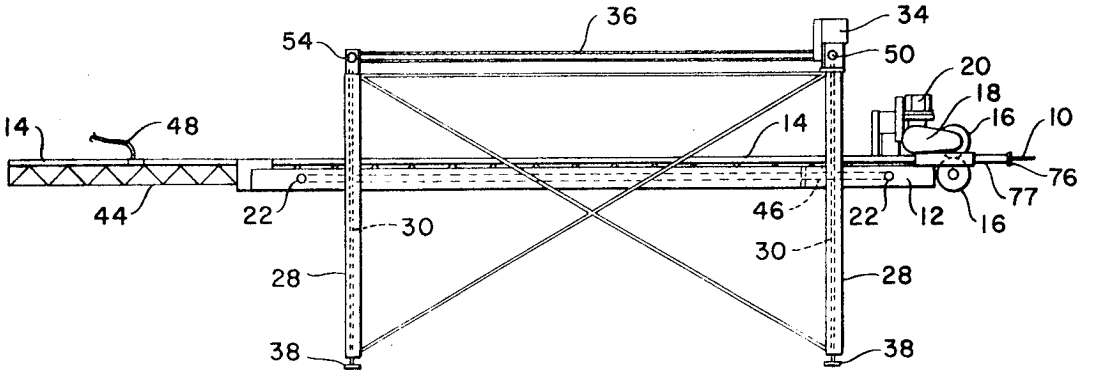


FIG. 4

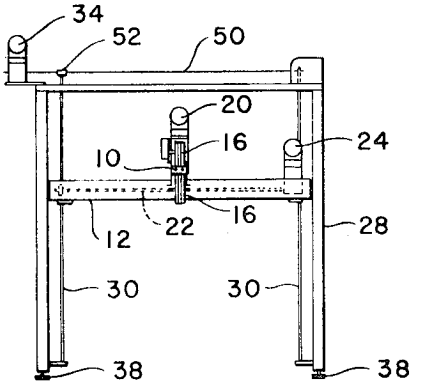


FIG. 5

INVENTORS:
ELVINO MARANGONI
DOUGLASS G. WEBB, JR.
BY: John M. Duncan
THEIR ATTORNEY

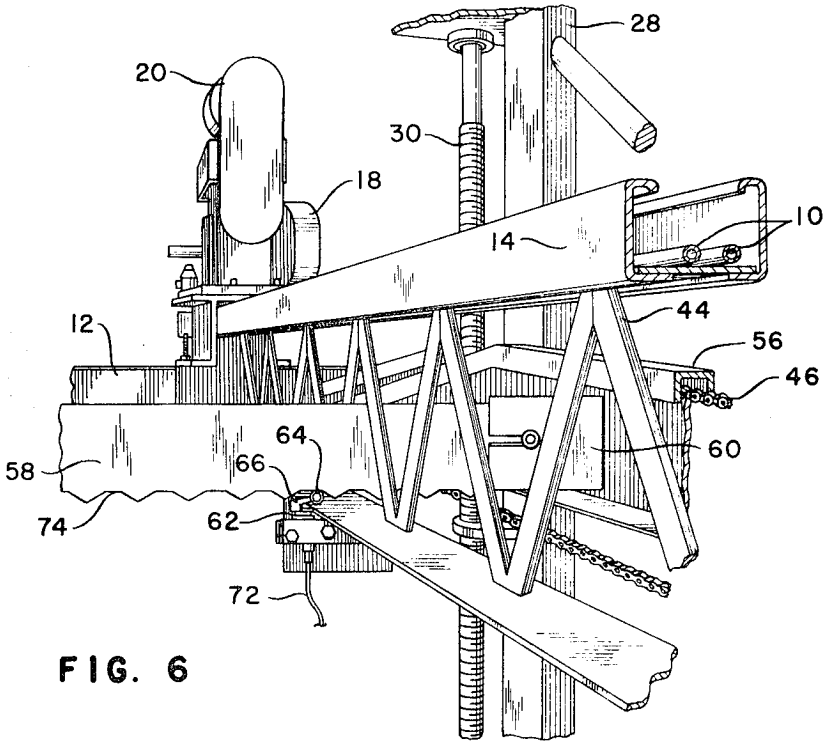


FIG. 6

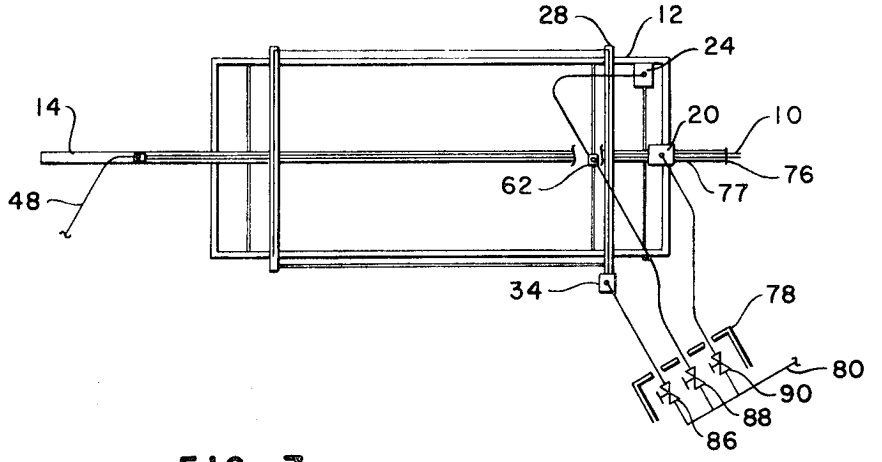


FIG. 7

INVENTORS:
ELVINO MARANGONI
DOUGLASS G. WEBB, JR.
BY: John M. Duncan
THEIR ATTORNEY

RODDING DEVICE

BACKGROUND OF THE INVENTION

Many industrial processes employ banks of tubes which are subject to becoming dirty and which require periodic cleaning. Examples of such processes are those wherein a liquid is heated in a furnace by flowing through hot tube banks, and material is heated by heat exchange between fluid carried in tubes and fluid carried in a surrounding shell. Many tubes so employed become clogged because of deposits originating in the liquid being heated or formed by the high temperatures of the metal in the tube. As a result, the heating process must be shut down periodically to remove deposits of material in that deposits will either eventually clog the tube so that fluid will no longer flow through it, or reduce the heat transfer through the tube wall to a point where it is not reasonable to obtain the desired temperature of the fluid, or both.

Cleaning of such tubes is difficult and costly in that it involves both manpower and downtime. Conventionally, such tube banks are cleaned by removing a head or other means provided to give access to the tubes and inserting a rod that either mechanically removes the deposits, that is by physically engaging them or drilling them out or brushing them with a stiff brush, or by hydraulically removing the deposits for example using a high pressure nozzle designed to direct a high energy spray against the tube walls. Rodding devices have also employed both mechanical engagement and hydraulic means for removing deposits.

Since the tubes contained in the tube banks characteristically are long, and since whatever rodding means are employed to remove deposits must be of smaller diameter than the tubes, preferably small enough so that an annular space exsits during rodding the the discharge of fluid and chips, there is a problem forcing a thin rod into a long tube without buckling of the rod. Rodding of tubes is conventionally accomplished by employing a group of men, one of which directs the end of the rod into the tube to be rodded and the others easing the rod into the tubes and being spaced along the rods so that it is supported without a "long column" that is capable of buckling.

The above described method for rodding tubes not only represents an extravagant use of manpower, but it is a dirty, wet, uncomfortable job that desirably is eliminated from the operation of a plant, and it additionally is an expensive procedure in that prolonged downtime during rodding results in a loss of product. Of course, the problems of manual rodding are exaggerated if the cleaning fluid or the material being removed from the tubes is toxic or irritating to human beings.

THE INVENTION

This invention, which solves or greatly mitigates all of the foregoing problems, involves a device and a method for using it, the device including a fluid carrying rod which is supplied with fluid at one end and a surface cleaning device at the other, the rod being supported on a rod carrying means supported on a carriage, the carriage including a motor driven device positioned near a vertical boundary of the carriage and to move the rod axially off of the rod holding means, the rod driving means being adapted to drive the rod into and retract the rod from tubes to be cleaned. The carriage is also provided with a means to move the rod

holding means and its associated rod driving means horizontally with regard to the normal orientation of the device. The entire carriage is held on a frame which is provided with means for moving the carriage vertically with regard to the normal orientation of the device and the frame preferably is provided with leveling means so that it can be oriented with the carriage horizontal.

The device described above functions so that one man can clean the entire tube bank without problems of inserting or retracting the rod, and as will be described, without problems of buckling of the rod. The device and its manner of use can best be described with reference to the accompanying drawings which illustrate an embodiment of the device claimed herein.

DRAWINGS

FIG. 1 is a perspective drawing of a suitable embodiment of the rodding apparatus for use herein.

FIG. 2 is a partially cutaway vertical cross section of the device of FIG. 1 as well as a partial vertical cross section of a tube bank being cleaned.

FIG. 3 is a plan view of the apparatus of FIG. 1.

FIG. 4 is an elevation view of the apparatus of FIG. 1.

FIG. 5 is an end view of the apparatus of FIG. 1.

FIG. 6 is a partially cut-away perspective view of a rod holding means and a motor stopping means for laterally positioning the fluid-carrying rod suitable for the device of FIG. 1.

FIG. 7 is a schematic illustration of the apparatus controls remotely located at a single operation station.

DETAILED DESCRIPTION

Referring to the drawings in which the same part has the same reference numeral in all views, two fluid-carrying rods **10**, which may be either rigid pipe or high pressure flexible hose capable of turning a **180** degree corner, are shown supported on a carriage **12** by rod holding means **14** which in this particular embodiment consists of a "trough" or U-channel mounted on a truss **44**. The fluid carrying rods are driven into and retracted from approximately horizontal tubes to be cleaned by means of friction rollers **16** which are connected by means of a suitably covered chain drive **18** to a gear reducer **68** and rotary air motor **20**. The friction rollers **16** are positioned closely adjacent to the end of the rod holding means **14** and aligned to pull rods **10** axially from rod holding means **14**. Friction rollers **16** are also positioned closely adjacent to the vertical boundary of the carriage **12** which faces the tubes to be cleaned so that a long, unsupported section of rod will be avoided in use and the fluid-carrying rods will not buckle if an obstruction is encountered as the rods are being inserted into the interior of said tubes.

The rod holding means **14** may be moved horizontally on the carriage **12** by means of traverse screws **22** (one of which is shown only at its bearing) which are driven by a reversible rotary air motor **24** which may be suitably positioned on the carriage **12** and may be connected to the traverse screws **22** by means of a gear reducer and chain drive **26**. The screws **22** are also inter-connected by conventional means, not shown, so that they move in the same direction and at the same rate when motor **24** operates. The carriage **12** is shown supported by a frame **28** which contains four elevation screws **30**, one in each corner, for moving the carriage

12 vertically. The elevation screws 30 may be activated by a rotary air motor 34 operating through an elevation screw drive mechanism 32 such as a gear reducer and chain drive. The carriage 12 may be maintained in a given orientation with respect to horizontal, usually horizontal, by simultaneously operating the elevation screws 30 at the same rate and in the same direction that mechanically inter-connect them, for example, a chain such as 36. Preferably, the frame 28 will have leveling means 38 to establish a horizontal orientation for carriage 12 so that the fluid-carrying rods 10 can be inserted without binding into the tubes which are to be cleaned. When two or more fluid-carrying rods are used the distance between the rod centers corresponds to the distance between the center lines of the vertical columns of tubes to be cleaned. This distance may be regulated by providing a rod separator plate 76 having holes spaced to correspond to the openings of the tubes. Preferably, plate 76 is held away from the rollers 16 by spacer 77 which has the added advantage of reducing the unsupported length of rods 10 to further reduce the possibility of buckling.

The partially cut-away elevation of FIG. 2 more clearly illustrates the apparatus as it operates. A fluid-carrying rod 10 having a suitable spray nozzle 40 is inserted into individual tubes 44 of a tube bundle 42. Such tubes may be either cleaned in place, e.g., in a furnace or in a heat exchanger shell, or a tube bundle may be removed from a heat exchanger shell and transported to a central cleaning area where the tube bundle may be placed in a horizontal position on a tube bundle support 70. This view illustrates how the fluid-carrying rods may be inserted into and retracted from the tubes 42 by means of friction rollers 16 connected by a chain drive 18 to a gear reducer 68 and a rotary air motor driver 20. The rod driving means 16 is shown positioned closely adjacent to the end of the rod holding means 14 and closely adjacent to the vertical boundary of the carriage 12. In this view the rod holding means 14 is shown supported by a truss 44, although other suitable supporting means could be provided. The cut-away illustrates how the carriage 12 may be raised and lowered vertically on the frame 28 by rotating the elevation screws 30 only one of which is illustrated. The shaft 50 and chain drive 36 for synchronizing the movement of the four elevation screws 30 are also shown in greater detail than in FIG. 1. The shaft 50, driven by chain 36, is connected by conventional means which are not shown, to effect rotation of screw 30.

It may be noted from FIG. 2 how buckling of rods 10 is prevented. There is no column strain on rods 10 while they are in holder 14. Rollers 16 create a column load on rods 10, but the column is maintained very short because either rollers 16, or when used separator plate 76 may be brought very close to tubes 44, and tubes 41 themselves prevent buckling of the portion of rods 10 within them.

FIG. 3 illustrates a means for synchronizing the movement of the two traverse screws 22 by means of a chain drive 46 between them. By operating both screws in the same direction and at the same rate, the axial relationship between rods 10 and tubes 41 is maintained during movement of the carriage, for ease of insertion of the rods 10 into the tubes. This embodiment also shows a flexible hose 48 for supplying high pressure fluid to the fluid carrying rod 10. Further, this view illustrates a method for synchronizing the operation of the elevation screws 30 so that the carriage 12 is kept level as it is raised or lowered. The rotary air motor 34 is shown driving a shaft 50 which is connected to a right angle gear 52 which rotates the elevation screws 30. The shaft 50 extends across the top of the frame 28 and is connected to another right angle gear 52 which operates an elevation screw 30 on the opposite side of the apparatus. The shaft 50 is connected by a chain drive 36 to a second shaft 54 located at the other end of the frame 28 to rotate two more right angle gears 52 which operate the remaining two elevation screws 30. Since the four screws 30 lie directly beneath the gears 52, they are not visible in this view.

FIG. 4 illustrates the rotary air motor 34 used to operate the elevation screws 30 and the chain drive 36 which connects shaft 50 and shaft 54, thereby synchronizing the rotation of the four elevation screws and thus maintaining the carriage 12 in a level position as it is raised or lowered on the frame 28. This view again illustrates the fluid-carrying rod 10 having a flexible hose 48 at one end for supplying high pressure fluid thereto and being supported on a carriage 12 by the rod holding means 14. This view also better illustrates the chain drive 46 used to connect and synchronize the operation of the traverse screws 22.

FIG. 5 illustrates a rotary air motor 34 used to raise and lower the carriage 12 by means of elevation screws 30. This view also illustrates a rotary air motor 24 which is used to operate traverse screws 22 and thus position the fluid-carrying rods 10 laterally on the carriage 12. The rotary air driver 20 and the friction rollers 16 for inserting and retracting the fluid-carrying rods 10 are also shown.

The perspective drawing of FIG. 6 shows a particular embodiment of the fluid-carrying rods 10 in relation to the rod holding means 14 which, in this case, consists of a "unistrut" split on the center line and stitch welded to the upper plate of the supporting truss 14. This view also shows in greater detail the chain drive 46 used to synchronize the two traverse screws 22 which position the rod holding means 14 and rod driving means 20 laterally on the carriage 12. In addition, this view illustrates a method which may be used to stop the motor means 24 (see FIG. 1) for horizontally positioning the rod holding means 14 and rod driving means 20 automatically so that the spray nozzle end of the fluid-carrying rod 10 is opposite from and in alignment with the center-line of the openings of a vertical column of tubes to be cleaned. A notched plate 58 is installed having notches 74 cut on one edge so that the distance between notches is the distance or a multiple of the distance between the center lines of the openings of the vertical columns of tubes to be cleaned. The notched plate 58 is positioned perpendicular to the rod holding means 14 and is temporarily attached to the carriage by a suitable bracket 60 so that it can be easily removed. Suitable notched plates having various distances between notch tips can be prepared for each type of tube bundle to be cleaned to aid in rapidly positioning the fluid-carrying cleaning rods 10 laterally on the carriage 12 to correspond to the tube openings. In this particular embodiment an automatic lateral rod positioning air valve 62 is attached to the truss 44 in such a manner that as the truss 44 and rod holding means 14 are moving laterally on the carriage 12 a roller 64 connected to an air valve 62 by a connecting arm 66 contacts the

notches 74 on the edge of the notched plate 58. When the truss moves laterally the roller 64 is depressed by the tip of one of the notches thereby closing air valve 64 and shutting off the air supply to rotary air motor 24 (see FIGS. 1 and 5). By stopping the motor 24 which drives the traverse screws 22 (see FIGS. 3 and 5) the fluid carrying rods 10 are automatically positioned in alignment with the center-line of the openings of a vertical column of tubes to be cleaned.

A similar notched plate may also be used to control rotary air motor 34 which raises and lowers the carriage frame 12 so that it is automatically stopped when the fluid-carrying rods 10 are vertically positioned for insertion into a row of tubes in a tube bundle.

The schematic drawing of FIG. 7 shows how the various motor controls may be located on a motor control panel 78 remotely located in a single operation station. For the particular embodiment shown the various motor and valve means are air-activated primarily as a safety precaution against ignition of an explosive atmosphere. However, said means may also be actuated by electricity or other suitable means.

Compressed air is supplied through main air supply line 80 to air control valves which actuate the various parts of the apparatus. Means for supplying and controlling high pressure fluid to the rods are well known in the art and will not be discussed here. Elevation screw air valve 86 controls elevation screw rotary air motor 34, which is used to raise and lower the carriage 12.

Manual lateral rod positioning air valve 88 controls the air supply to the automatic lateral rod positioning air valve 62 which in turn automatically stops the lateral rod positioning rotary air motor 24, as explained above in the discussion of FIG. 6, to align the fluid-carrying rods 10 with the openings of vertical columns of tubes to be cleaned.

Rod driver air valve 90 controls the air supply to the rod driver rotary air motor 20 which drives the fluid carrying rods 10 into and retracts them from the tubes to be cleaned.

The control panel 78 is suitably mounted inside a glass enclosed booth having windshield wipers mounted thereon. This enclosure enables a single operator to observe the apparatus in operation and to control said operation without using waterproof protective clothing to avoid being sprayed with cleaning fluid.

Although the apparatus described herein will most frequently be used for cleaning heat exchanger tube bundles or furnace tubes which are open on both ends it can also be employed to clean U-tube bundles or furnace tubes. This is accomplished by substituting high pressure flexible hose for the fluid-carrying rod. By providing flexible hose of sufficient length both legs of a U-tube can be cleaned by inserting the spray nozzle in only one end.

When the apparatus is used to clean heat exchanger tube bundles it is conveniently located in an area remote from the operating unit. Tube bundles 42 are conveniently removed from a heat exchanger shell and transported to the cleaning area where they are placed on the tube support 70 which preferably contains rollers 71 on which the tube bundles 42 may be rotated until the rows of tubes 41 are horizontal. The bundle support 70 is suitably placed in a substantially horizontal position so that the individual tubes 41 are substantially horizontal when the bundle 42 is placed on the rollers 71.

To begin the process of cleaning tubes the operator first levels the carriage 12 to a substantially horizontal position by adjusting the leveling and positioning means 38. He then raises or lowers the carriage 12 by actuating the elevation screw rotary air motor 34 until the fluid-carrying rods 10 are on the same level as a row of tubes 41. The operator then moves the rod holding means 14 laterally by actuating rotary air motor 24 until the fluid-carrying rods 10 are aligned with the tubes at one end of the row. The operator then actuates the rod driving means 20 to insert the rods 10 into the tubes 41. When the rods are inserted into the tube the operator starts high pressure fluid passing through the rods. When the rods 10 reach the end of the tubes 41, the flow of high pressure fluid may be stopped. The rod driving means 20 is reversed to retract the rods 10 from the tube 41.

Moveable stops may be placed on the rod holding means 14 to limit the forward and reverse travel of the rod to correspond to the length of the tubes to be cleaned.

When the device is set up for automatic horizontal cleaning operation the operator activates the lateral rod positioning air valve 62 which moves the rod holding means 14 a lateral distance to align the fluid-carrying rods 10 with the next tubes to be cleaned. The fluid-carrying rods are again inserted into the tubes and the cleaning process is repeated.

While the preferred embodiment of the invention has been described for purposes of illustration, it is understood that the invention embraces such other modifications and variations as come within the scope and spirit thereof. It is also understood that it is desired that the scope of the invention be limited only by the claims thereof.

We claim as our invention:

1. An apparatus adaptable for cleaning the interior surface of substantially horizontal tubes comprising in combination:

a. an upright structural frame;

b. a vertically adjustable carriage mounted on said frame and adapted to be moved in an essentially vertical plane by connectible motor means;

c. horizontally adjustable means mounted on said carriage adaptable to support and maintain at least one elongated fluid-carrying rod in substantially horizontal axial alignment with said tubes, and adapted to be moved in an essentially horizontal plane perpendicular to the tube lengths by connectible motor means;

d. motor control means mounted on said carriage adapted to position said elongated rod for insertion into the opening of said tubes by automatically stopping the horizontal alignment motor means;

e. rod driving means mounted on said carriage closely adjacent to the tube-side of said carriage so as to prevent buckling of said rod during said insertion, and adapted to insert said rod into and withdraw it from said tube by connectible motor means.

2. The apparatus of claim 1 wherein said motor control means comprises a notched plate mounted perpendicular to the tube lengths and a motor control switch operatively engaged to said notched plate.

3. The apparatus of claim 1 wherein said fluid-carrying rod has a conduit for supplying high-pressure

fluid attached to one end and a tube surface cleaning device attached to the other end.

4. The apparatus of claim **3** wherein the surface cleaning device is a high-pressure liquid spray nozzle.

5. The apparatus of claim **1** wherein the frame has leveling and positioning means.

6. The apparatus of claim **1** wherein the means for vertically positioning the carriage, for laterally positioning the fluid-carrying rod, for driving the rod into and retracting the rod from said tubes, and for controlling the flow of high-pressure fluid to said rod are remotely controlled from a single operation station.

7. The apparatus of claim **1** wherein the rod driving means are friction rollers actuated by motor means.

8. The apparatus of claim **1** wherein said rod is a high-pressure flexible hose.

9. A process for cleaning the interior surface of substantially horizontal tubes utilizing the combination apparatus of claim **2** which comprises:

a. aligning said apparatus with a horizontal row of tubes so that the fluid-carrying rod can be readily inserted into said tubes;

b. inserting said rod into said tubes and supplying high-pressure cleaning fluid to said rod;

c. driving said rod into and withdrawing it from said tubes, whereby cleaning is effected by said cleaning fluid impinging against said interior surface;

d. adjusting said fluid-carrying rod horizontally on the carriage in axial alignment for entry into an adjacent tube, said rod being positioned automatically by the notched plate and horizontal motor control switch;

e. repeating steps (b), (c) and (d) for the tubes remaining in said horizontal row; and

f. adjusting the carriage vertically and repeating the process.

10. The process of claim **9** wherein the operation is remotely controlled from a panel mounted inside an enclosure adapted to shield an operator from cleaning fluid spray.

* * * * *