

Sept. 10, 1968

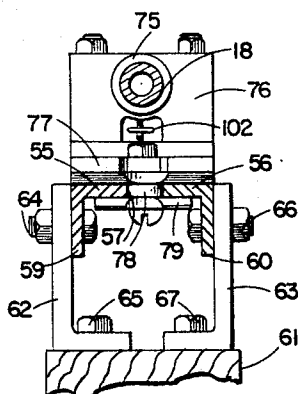
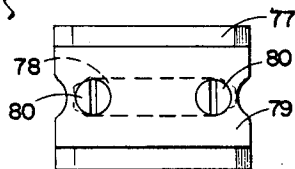
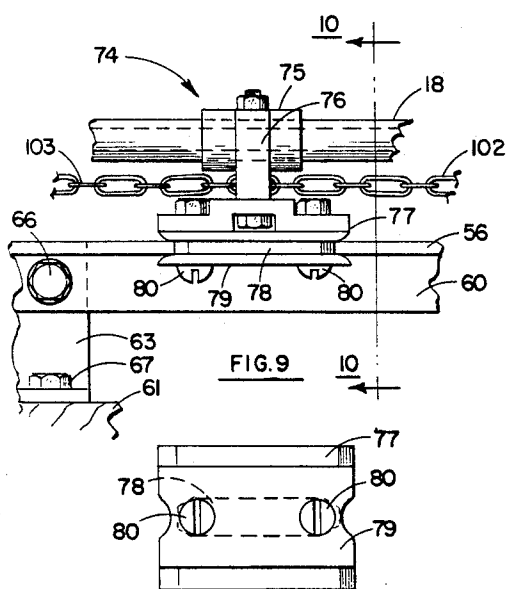
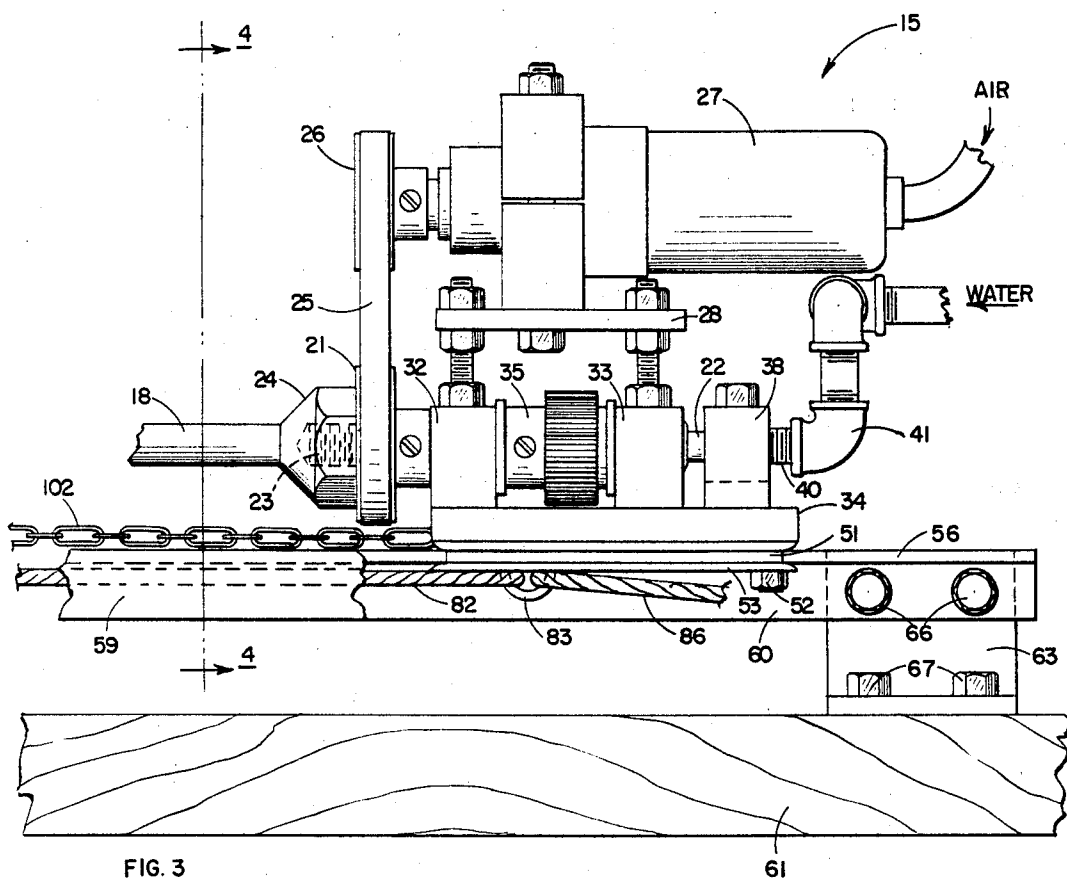
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3,400,419

TUBE-CLEANING DEVICE

Filed March 21, 1966

4 Sheets-Sheet 2



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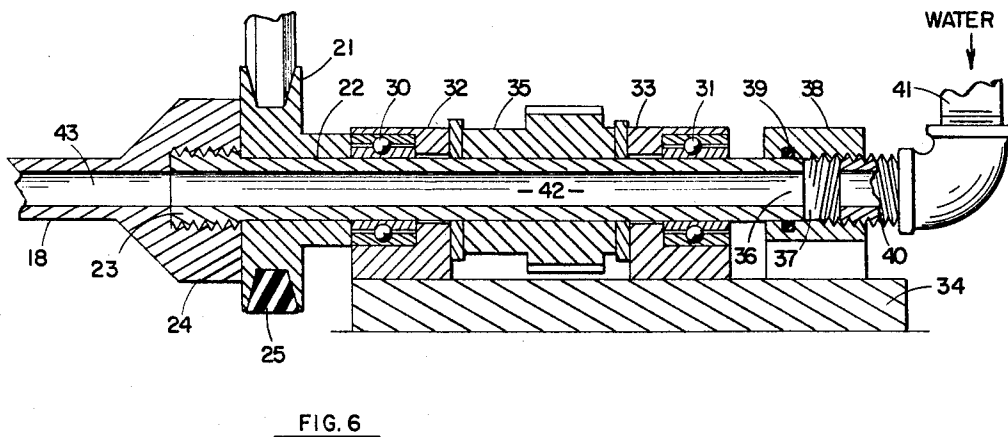
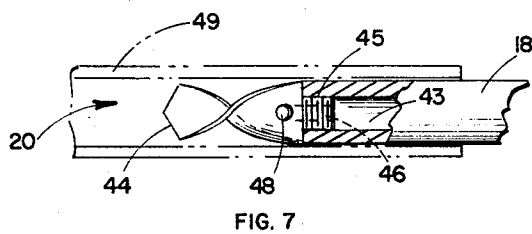
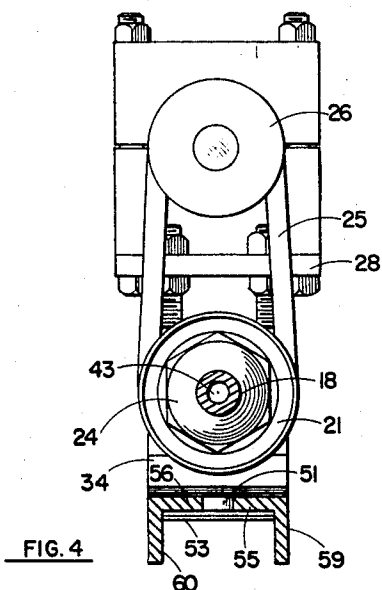
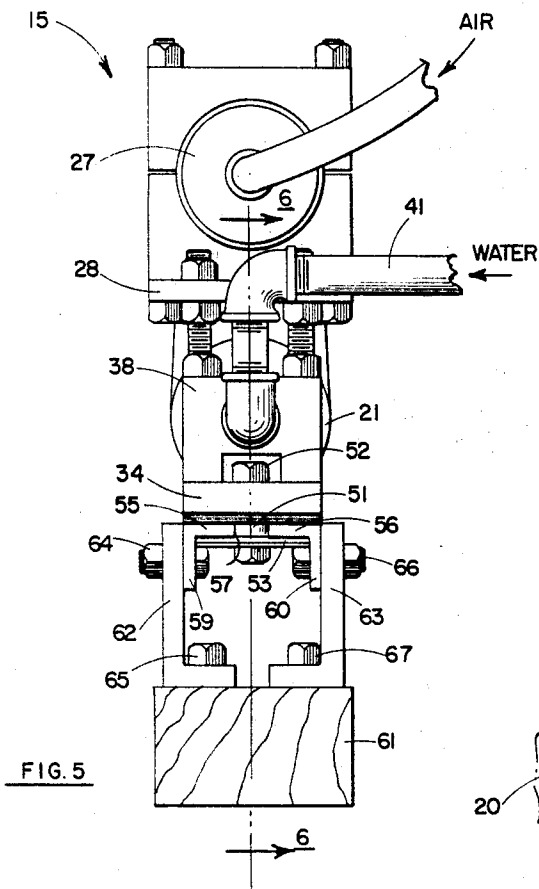
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3,400,419

TUBE-CLEANING DEVICE

Filed March 21, 1966

4 Sheets-Sheet 3



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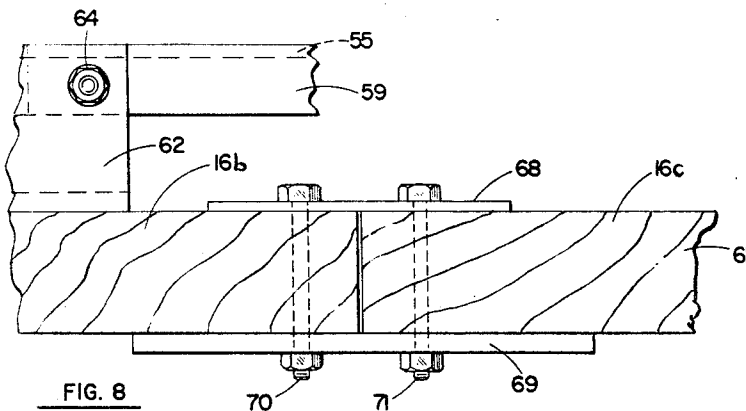
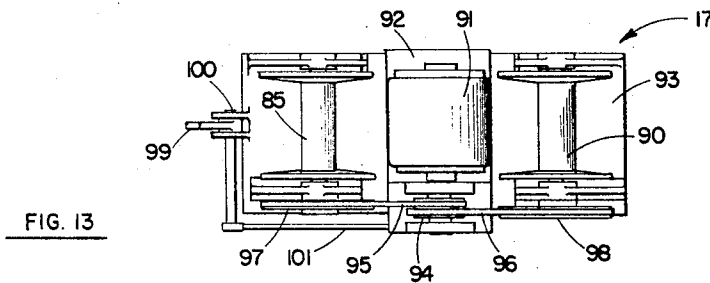
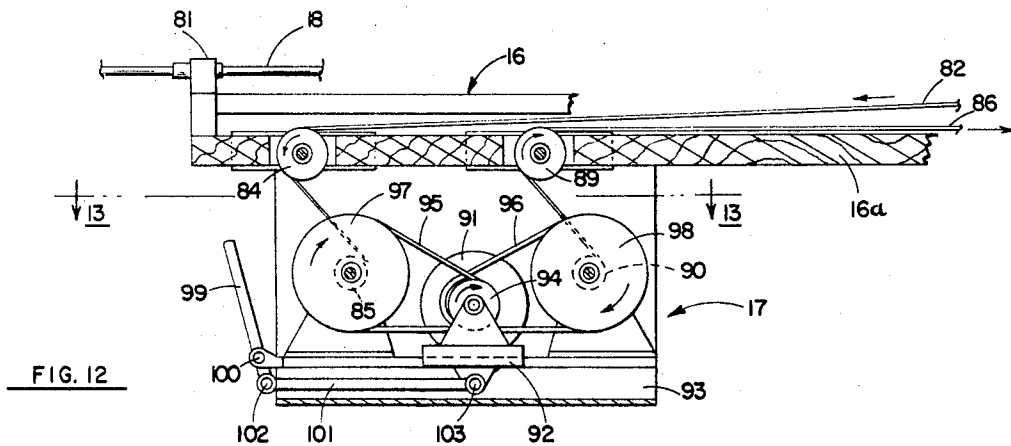
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TUBE-CLEANING DEVICE

Filed March 21, 1966

4 Sheets-Sheet 4



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TUBE-CLEANING DEVICE

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Filed Mar. 21, 1966, Ser. No. 535,755
10 Claims. (Cl. 15—104.1)

ABSTRACT OF THE DISCLOSURE

A tube cleaning device including a track, a carriage movable on the track, and an elongated shaft rotatable by a drive unit on the carriage, the elongated shaft having a cutting bit at its outer end. At least one bearing is provided on the track to support the shaft, the bearing means being movable with the carriage during part of the movement of the carriage.

This invention pertains to a device for cleaning tubular members.

While the device of this invention is of general utility in cleaning tubular members, it is particularly useful for cleaning the tubes of heat exchangers found in oil refineries. Typically, a refinery will have several heat exchangers in various locations, some of which are elevated in height or inaccessible due to the presence of other equipment. After a period of service, deposits will form in the heat exchanger tubes, obstructing or completely blocking fluid flow and impairing the efficiency of the unit. This requires cleaning of the tubes to remove the material that has formed inside them. Conventionally, it has been the practice to clean the tubes by a slow laborious manual cleaning process, generally requiring removal of the bundle of tubes from the heat exchanger. My previous invention, found in Patent 2,803,842, represents a mechanized arrangement for cleaning tubes constituting a substantial improvement over the old hand methods. This development utilizes a power-driven rotary bit advanced through the tube to be cleaned by a power cylinder. While a good deal faster than the hand method of tube cleaning, the device of this patent has certain disadvantages. Because it is necessary to advance the bit by a power cylinder, the unit always occupies considerable space due to the necessity of having a long cylinder for obtaining an adequate stroke. Consequently, the device will not fit into many locations, so that frequently it is necessary to remove the bundles of tubes from the heat exchangers as before. Moreover, the device is comparatively cumbersome and heavy, which restricts its portability and the ease of its use. Also, there is an inherent problem in use of the rotary bit which realizes its axial movement through the force of a power cylinder. This means that the seals and connections between the parts are subject to failure, so that frequent maintenance is needed. This also limits the speed of rotation, which reduces the effectiveness of the cutting action of the bit. Finally, the power cylinder drive and the overall construction of the unit make it a costly type of item to construct.

The present invention provides a tube-cleaning device which is truly portable and will fit into small spaces, so that the tubes may be cleaned without removal from the heat exchanger. It has numerous other advantages including its simple and reliable construction, rapid rotation of the bit, improved advancing arrangement for the bit and adjustability in the length of the stroke. The device includes a carriage which is advanced along a track by a pull from a cable beneath the track. The track may be mounted on a wooden beam which is in sections, so the

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length of movement and the space occupied by the unit can be controlled. The carriage drives a bit at the end of a tube which carries water to the cutting edges to wash away the material and keep the bit cool. This tube is supported at spaced locations by bearings which are movable along the track. As the carriage is advanced in moving the bit forwardly, the bearing supports for the drive tube are pushed ahead of the carriage as they are reached. Thus, they do not interfere with the movement of the carriage. After the stroke is complete, when the carriage is returned, a flexible connection to the bearing supports automatically moves them back along the track to their original locations.

An object of this invention is to provide an improved tube-cleaning device.

Another object of this invention is to provide a tube-cleaning device that is light in weight and portable.

A further object of this invention is to provide a tube-cleaning device which occupies a relatively small space and which has an adjustable stroke, permitting reduction in overall size when shorter tubes are to be cleaned.

Yet another object of this invention is to provide a tube cleaning device that is readily assembled and disassembled.

A still further object of this invention is to provide a tube-cleaning device having rapid speed of the cutting bit, while also having reliable maintenance-free long-life operation.

An additional object of this invention is to provide a tube-cleaning device which is economical to construct and operate.

These and other objects will become apparent from the following detailed description taken in connection with the accompanying drawings in which:

FIGURE 1 is an elevational view of the tube-cleaning device of this invention with the carriage in the retracted position;

FIGURE 2 is a view similar to FIGURE 1 but with the carriage advanced through a portion of its stroke;

FIGURE 3 is an enlarged fragmentary side elevational view, partially broken away, illustrating the carriage unit and its connection to the track;

FIGURE 4 is a transverse sectional view taken along line 4—4 of FIGURE 3, illustrating the front end elevation of the carriage;

FIGURE 5 is a transverse sectional view taken along line 5—5 of FIGURE 3, showing the rear elevational view of the carriage;

FIGURE 6 is a fragmentary longitudinal sectional view of the lower portion of the carriage unit, taken along line 6—6 of FIGURE 5;

FIGURE 7 is an enlarged fragmentary elevational view, partially broken away, of the cutting bit at the outer end of the drive tube;

FIGURE 8 is an enlarged fragmentary view illustrating the connection between the track sections;

FIGURE 9 is a fragmentary side elevational view of one of the bearings for the drive tube;

FIGURE 10 is a transverse sectional view taken along line 10—10 of FIGURE 9;

FIGURE 11 is a bottom plan view of the bearing support of FIGURE 9;

FIGURE 12 is an enlarged side elevational view of the drive unit for moving the carriage;

FIGURE 13 is a sectional view taken along line 13—13 of FIGURE 12; and

FIGURE 14 is a fragmentary side elevational view showing the mounting arrangement for the aft end pulley of the carriage moving system.

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As seen in FIGURES 1 and 2, the device of this invention includes a carriage 15, movable along a path defined by a track assembly 16 by a drive unit 17. An elongated tube 18 extends forwardly from the carriage and at its outer end carries a cutting bit 20. In general, in the operation of the device the carriage moves forwardly along the track 16 from its retracted position, advancing the cutting bit 20 to clean out the tube of a heat exchanger. The tube 18 acts as a drive shaft to rotate the bit as it moves through the heat exchanger being cleaned.

With reference to the detailed illustrations of FIGURES 3 through 6, the carriage assembly 15 includes a pulley 21 driving a shaft 22 having a threaded end 23 extending into the inner end portion 24 of the tube 18. The pulley 21 is rotated by a belt 25 which, in turn, is driven by a pulley 26 powered by an air motor 27 mounted on a support 28 at the upper portion of the carriage assembly. It is possible to use an electric motor in lieu of the air motor 27, but for refinery use safety regulations require air as the power source.

The shaft 22 extends through two ball bearings 30 and 31 carried by blocks 32 and 33 supported, in turn, by a base 34 of the carriage assembly 15. A spacer 35 is interposed between the two bearings 30 and 31. Beyond the rearward bearing 31, the shaft 22 includes a reduced diameter portion 36 that fits into an opening 37 in an additional block 38. An O-ring 39 provides a seal between the rotary shaft 22 and the stationary block 38. A nipple 40 is threaded into the opening 37, with a water inlet line 41 being connected to it. Therefore, water from the inlet 41 will enter the bore 42 of the shaft 22, which conducts it to the bore 43 of the elongated drive tube 18.

The cutting bit 20 which is carried by the distal end of the tube 18 is a short member having a V-shaped forward end 44 and a threaded shank 45 that extends into the end of the tube 18 (see FIGURE 7). The shank 45 has a bore 46 through it which leads, in turn, to a pair of outlet openings 48, which are forwardly inclined. Thus, water entering from the inlet 41 will travel through the bores 42 and 43 to the cutting bit 20, where it is discharged toward the forward cutting end 44 through the openings 48. As a result, as the bit 20 is advanced through the heat exchanger tube 49, the water will flush away the material cut from the interior of the tube, also cooling the bit so that it can be rotated and advanced rapidly. This simple water-feed arrangement assures that a fully adequate volume of water can be provided to achieve these results.

The base 34 of the carriage includes a narrow central rib portion 51 connected by bolts 52 to a lower plate 53. As best seen in FIGURE 5, this provides a connection between the carriage and the track as the base 34 rests upon opposed parallel flanges 55 and 56 of the track, while the rib portion 51 extends through the elongated slot 57 between the two flanges. The lower plate 53 completes the connection to the track, so that the carriage cannot be moved upwardly and is confined to the rectilinear path defined by the flanges 55 and 56 and the slot 57.

The flanges 55 and 56 are defined by the upper portions of a pair of steel angles 59 and 60 which are supported above a wooden beam 61 at spaced locations by means of brackets 62 and 63. The bracket 62 connects by bolts 64 to the angle 59 and by screws 65 to the beam 61. Similarly, bolts 66 connect the angle 60 to the bracket 63, which is joined to the beam 61 by screws 67.

The track assembly is segmented, in the example illustrated being made up of forward section 16a, intermediate section 16b and a rearward section 16c. In a typical construction, each section will be seven feet in length. The sections are secured together, as illustrated in FIGURE 8, through the use of upper and lower plates 68 and

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69 at each juncture, secured through the adjacent beam sections by bolts 70 and 71. The ends of the sections of the steel angles that define the track are butted together and in alignment at the connecting points of the track assembly.

Also, slidably mounted on the track assembly 16 are bearings 73 and 74, which support intermediate portions of the elongated tube 18. The details of the bearing support 74 are shown in FIGURES 9, 10 and 11, with the other bearing support 73 being identical. A cylindrical sleeve 75 receives the tube 18 and acts as the bearing for it. The sleeve is carried by an upstanding member 76 mounted on a base 77. Depending from the central portion of the base 77 is a narrow intermediate rib section 78, below which is a base flange 79. The section 78 extends through the slot 57 between the upper flanges 55 and 56 of the track, while the lower part 79 fits beneath these flanges. The elements 77, 78 and 79 are held together by a pair of bolts. Therefore, the base 77, intermediate portion 78 and bottom part 79 confine the bearing support 74 to the path of the track, permitting it to slide along the track.

In addition to the movable bearing supports 73 and 74, there is a fixed end bearing 81 at the forward end of the track assembly 16. This also includes a sleeve bearing through which the tube 18 passes. The cutting bit 20, of course, is beyond the forward bearing 81 even when the carriage 15 is in its retracted position.

The carriage is moved forwardly along the track 16 by a cable 82 that connects to a fitting 83 mounted beneath a lower plate 53 of the carriage unit. The cable 82 extends forwardly from the carriage 15 beneath the track assembly and around an idler pulley 84 at the forward end of the track assembly adjacent the front bearing 81. The end of the cable 82 is wound around a drum 85. A second cable 86 also connects to the fitting 83, extending rearwardly from it to a pulley 87 mounted on a bracket 88 supported on the rearward end of the aft track section 16c. From there, the cable 85 extends forwardly also beneath the track to pass over an idler pulley 89, which is immediately behind the pulley 84. A drum 90 receives the end of the cable 86.

A motor 91 can selectively drive the drums 85 and 90, as illustrated in the detailed views of the drive unit found in FIGURES 12 and 13. The motor 91 is mounted on the base 92 that is slidably mounted on the support 93 for the drums 85 and 90. In other words, the motor 91 can move a limited distance parallel to the path defined by the track assembly 16. At the outer end of the drive shaft that extends from the motor 91 is a pulley 94 having a pair of circumferential grooves in its surface around which extend belts 95 and 96. The former extends around a pulley 97 that is connected to the drum 85, while the belt 96 goes to a pulley 98 that is coupled to the drum 90. Movement of the motor is accomplished by a lever 99 pivotally mounted by a pin 100 with respect to the base 93. At the bottom end of the lever, beneath the pivotal mounting pin 100, a link 101 connects to the lever 99 by a pin 102. The opposite end of the rod 101 connects by a bearing 103 to the bottom of the support 92 that carries the motor 91.

By this construction, if the lever 99 has been moved forwardly, or counterclockwise as the device is viewed in FIGURE 12, the rod 101 will have shifted the base 92 of the motor 91 to the rear, or to the right, as the unit is illustrated. This causes the pulley 94 to assume driving engagement with the belt 95, while the other belt 96 is slack and not influenced by the pulley 94. This is the position shown in FIGURE 12. As a result, when the motor 91 rotates its drive shaft in a clockwise direction, it will also impart clockwise movement to the pulley 97 and to the drum 85. This pulls forwardly on the cable 82, which causes the carriage 15 to advance along the track assembly 16 toward the forward end of the track.

Conversely, if the lever 99 is pushed back, or clockwise as the device is shown in FIGURE 12, the base 92

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is pulled forwardly so that the drive pulley 94 engages the belt 96, causing the pulley 98 and drum 90 to rotate in the clockwise direction. This pulls on the cable 86 so that its other end, which extends around the pulley 87 at the rearward end of the track, draws the carriage 15 to the rear. In this manner, there is provided a selective drive for the carriage, by which it may be moved forwardly or rearwardly along the track assembly 16.

In operation of the device, it is positioned adjacent a heat exchanger so that it faces the bundle of tubes inside. It is aligned with one of the tubes to be cleaned, with the carriage in its retracted position toward the aft end of the unit. Then the motors 27 and 91 are started and the carriage 15 is moved forwardly along the tracks. Simultaneously, water is admitted through the inlet 41, discharging through the bores 42, 43 and 46 to the cutting portion of the bit 20. As the carriage moves along the track 16, the bit 20 advances through the tube, cleaning out the interior of the tube even where the tube is completely plugged. The cleaning of the tube is a relatively fast operation in view of the high speed of rotation permitted for the drive shaft 18 and the ample supply of water provided at the area of the cutting bit.

As the carriage 15 moves along the track, the hub section 24 of the drive tube 18 will be brought into engagement with the sleeve of the bearing 73. Continued advancement of the carriage 15 then causes the bearing 73 to be pushed ahead of the carriage along the track 16. After additional movement, the bearing 74 is reached and engaged by the bearing 73. Then, as the carriage moves forwardly, the bearing 74 is pushed ahead of the carriage immediately in front of the bearing 73. Thus, the two bearings 73 and 74 move with the carriage through its last increment of travel until the full stroke has been reached, the maximum length of which is determined by the position of the forward bearing 81.

When the carriage 15 is returned to its retracted position, the bearings 73 and 74 automatically are pulled back to the positions they formerly occupied. This is accomplished through the provision of a pair of chains 102 and 103. The former connects to the forward end of the base 34 of the carriage, extending to the rearward bearing 73. The second chain 103 extends between the two movable bearings 73 and 74. As the carriage moves rearwardly, initially it will move away from the two bearings 73 and 74, which remain adjacent the forward end of the track and the fixed bearing 81. After a predetermined amount of travel, however, the chain 102 will become taut between the bearing 73 and the carriage, so that as the carriage moves further to the rear, it pulls the bearing 73 at the end of the chain. After an additional increment of movement, the next chain 103 is pulled tight, and thereafter the forward bearing 74 is moved along with the carriage. This distributes the bearings 74 and 73 along the track assembly 16 in the set locations established by the lengths of chains 102 and 103. This arrangement, therefore, assures that there is full support for the shaft 18 throughout its length so that it can be rotated rapidly and free of vibration. At the same time, the intermediate bearings do not obstruct the progress of the carriage, so that the cutting bit is permitted a long stroke of travel. This permits it to pass through an elongated tube of the heat exchanger. Return movement of the carriage automatically repositions the bearings so that there is always support for the shaft 18 at the required positions along its length.

After the carriage has been moved back to the retracted position following the cleaning of a tube, the bit then is advanced through the next tube in the bundle, and progressively throughout the bundle until the entire heat exchanger has been cleaned.

Part of the versatility of the device of this invention lies in the adjustability of the length of the stroke of the carriage, which concomitantly permits the length of the unit itself to be changed. This construction also allows the device to be easily assembled or disassembled at any job site.

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In the example described above, the three seven-foot track sections 16a, 16b and 16c permit a maximum stroke of around twenty feet. For cleaning shorter tubes, sections of the track can be removed and a shorter drive shaft supplied in place of the longer shaft 18 used with the three track sections. For example, therefore, the carriage may be advanced onto the intermediate track section 16b and the aft section 16c removed from the assembly. The bolts 70 and 71 are loosened so that the rear portion of the track is separated quite readily. The pulley 87 is then positioned on the aft end of the section 16b, so that it will serve to receive the rearward part of the cable 86. The bracket 88 for the pulley 87 is secured to the track by a removable pin 104 (see FIGURE 14). To move the pulley 87, therefore, the pin 104 is pulled from the aperture that receives it at the end of the track section 16c and inserted instead through the opening in the end of the track section 16b formerly occupied by the bolt 70. There is no difficulty, therefore, in moving the idler pulley at the aft end of the drive cable assembly. Of course, the cables 82 and 86 are simply wound further onto the drums 85 and 90 to accommodate the additional slack occasioned by the shortening of the travel of the carriage 15.

This arrangement, therefore, permits the unit to be built up in convenient lengths of track section, allowing it to provide a stroke of almost any desired length. The light weight of the components facilitates their handling as the unit is assembled to provide the necessary stroke. Moreover, this light weight assures that the unit can be moved about as needed and is easily positioned adjacent the heat exchanger regardless of the location of the heat exchanger. There is no difficulty in lifting the unit to locate it where it is needed without the cumbersome and expensive use of elaborate hoisting equipment. The tube-cleaning arrangement of this invention, therefore, not only accomplishes its function much more rapidly than prior designs, but is more versatile and much easier to use. The same basic equipment is used regardless of the length of stroke of the cutting bit, and transfer from one stroke length to the other is effected rapidly and easily. Over and above this, the components of the device are relatively simple, resulting in a construction that is economical to manufacture and use and reliable in its operations.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

I claim:

1. A tube-cleaning device comprising
a track defining a path,
means movable along said path,
an elongated member,

said means including drive means engaging one end portion of said elongated member for rotating said elongated member during movement of said first-mentioned means along said path,

- at least one bearing means on said track supporting said elongated member, said bearing means being normally spaced from said movable means and movable with said movable means during less than the entire amount of movement of said movable means,
a cutting bit carried by the opposite end of said elongated member and adapted to enter a tube to be cleaned during said movement and rotation,
said elongated member having a bore there-through,

said bore having an outlet adjacent said cutting bit for discharging a fluid from said bore in the vicinity of said bit,

- and fluid inlet means connected to said bore for introducing such a fluid therein.

2. A device as claimed in claim 1 in which said track includes a plurality of sections in end-to-end alignment,

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and means removably holding said sections together for permitting the length of said track to be varied.

3. A tube-cleaning device comprising

a track defining a path,

means movable along said path,

an elongated member,

said means including drive means engaging one end portion of said elongated member for rotating said elongated member during movement of said first-mentioned means along said path,

a cutting bit carried by the opposite end of said elongated member and adapted to enter a tube to be cleaned during said movement and rotation,

said elongated member having a bore there-through,

said bore having an outlet adjacent said cutting bit for discharging a fluid from said bore in the vicinity of said bit,

fluid inlet means connected to said bore for introducing such a fluid therein,

at least one bearing for said elongated member,

said bearing including support means on said track and movable relative thereto,

said bearing being movable by said movable means in one direction upon movement of said movable means through a predetermined increment of movement in said one direction to a position of adjacency with said bearing,

and means interconnecting said bearing and said movable means for moving said bearing with said movable means in the opposite direction along said path upon movement of said movable means in said opposite direction through substantially said increment to a position remote from said bearing.

4. A tube-cleaning device comprising

an elongated track defining a rectilinear path,

a carriage movable along said track,

an elongated shaft,

a cutting bit at one end of said shaft,

drive means on said carriage,

the opposite end of said shaft being connected to said drive means for rotational movement thereby,

said shaft having a bore having an outlet opening adjacent said cutting bit,

fluid inlet means at said carriage for introducing fluid into said bore for conducting fluid through said bore to discharge adjacent said cutting bit, means for moving said carriage along said track for thereby advancing said shaft so that said cutting bit can extend into a tube to be cleaned,

and at least one normally stationary bearing means on said track supporting said elongated shaft, said bearing means being normally spaced from said carriage and movable with said carriage following movement of said carriage through a predetermined increment in so advancing said shaft.

5. A device for cleaning tubular members comprising

an elongated track defining a rectilinear path,

a carriage means movably mounted on said track,

a rotatable member on said carriage means,

power means for rotating said member,

an elongated tube coupled to said member,

said tube and said member having interconnected bores therethrough,

fluid inlet means connected to said bore of said member for introducing a fluid into said bores,

a cutting bit at the distal end of said tube,

said bores having outlet means adjacent said cutting bit,

bearing support means for said tube intermediate said distal end and said carriage means,

and means for advancing said carriage means along said track in one direction from a retracted position

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to an extended position simultaneously with the rotation of said tube by said drive means,

and for returning said carriage means in the opposite direction from said extended position to said retracted position,

said bearing support means being engageable by said carriage means upon said advancement of said carriage means along said track in said one direction,

said bearing support means being slidably mounted on said track for movement with said carriage means in said one direction upon said engagement.

6. A device as recited in claim 5 in which

said track is in sections,

and includes removable means for holding said sections together in aligned relationship,

for permitting adjustment of the stroke of said carriage means by assembling a predetermined number of said sections of said track.

7. A device as recited in claim 5 including in addition a flexible member interconnecting said carriage means and said bearing support means,

said flexible member having a predetermined length,

whereby upon said return of said carriage means to said retracted position said carriage means pulls said bearing support means with it upon movement of said carriage means in said opposite direction a distance corresponding to said predetermined length and positions said bearing support means at a predetermined location on said track as established by said predetermined length of said flexible member.

8. A device as recited in claim 5 in which

said means for advancing said carriage means includes

a cable means attached to said carriage means,

said cable means having two portions extending from said carriage means to the forward end of said track,

a pulley rearwardly of said carriage means,

one of said portions of said cable means extending over said pulley and from thence to said forward end,

and means for selectively pulling on either of said portions of said cable means for thereby selectively advancing and retracting said carriage means.

9. A device as recited in claim 8 in which

said track includes a plurality of sections in end-to-end alignment,

and removable means holding said sections together for permitting the length of said track to be varied by utilizing selected numbers of said sections,

said pulley including mounting means selectively engageable with the rearward end portions of said sections for permitting said pulley to be positioned rearwardly of said carriage means in different combinations of said sections.

10. A device as recited in claim 9 in which

said track sections include beam members,

said removable means including connecting members engaging both of adjacent ones of said beam members,

and fasteners extending through said connecting members and into said adjacent beam members, said mounting means for said pulley including a bracket, and a pin,

said bracket being adapted to engage a beam member in lieu of a connecting member upon removal of such a connecting member,

said pin being adapted to extend into a beam member engaged by said bracket in lieu of a fastener upon removal of such a fastener,

whereby said pulley is attachable to said track rearwardly of said carriage means when the length of said track is varied.

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