

March 8, 1966

O. C. HUFF ETAL

3,239,077

APPARATUS FOR MOVING HEAT EXCHANGER TUBE BUNDLES

Filed Nov. 21, 1957

4 Sheets-Sheet 1

FIG. 1.

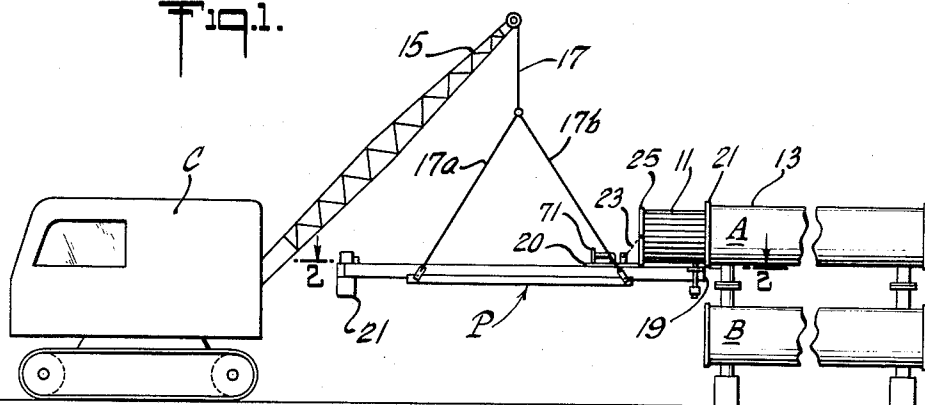
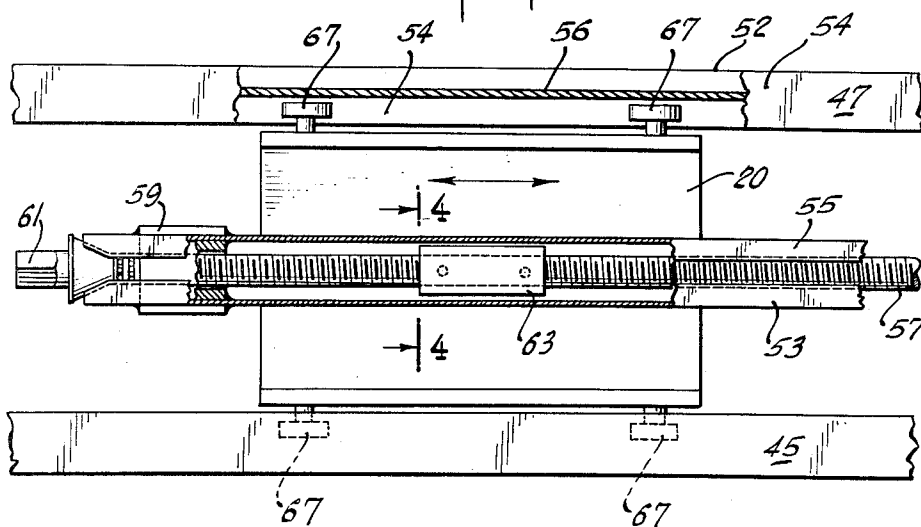


FIG. 2.



FIG. 3.



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Fig. 4.

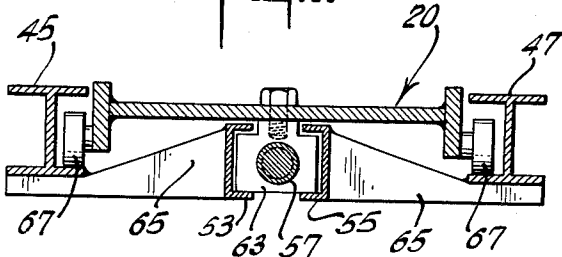


Fig. 5.

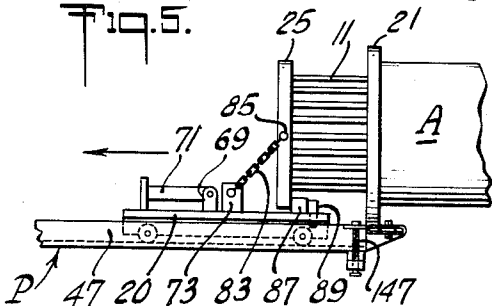


Fig. 6.

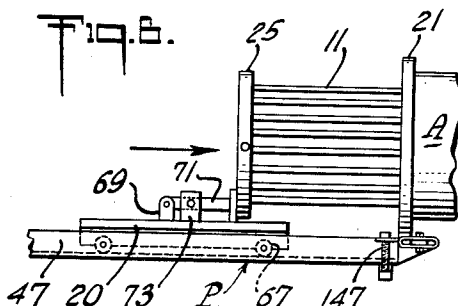


Fig. 13.

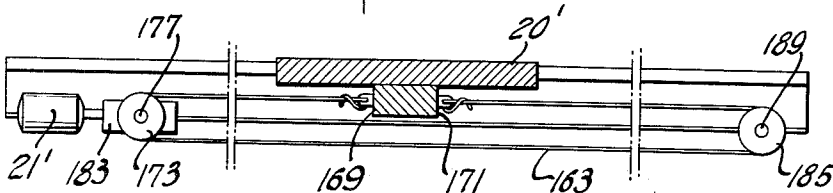
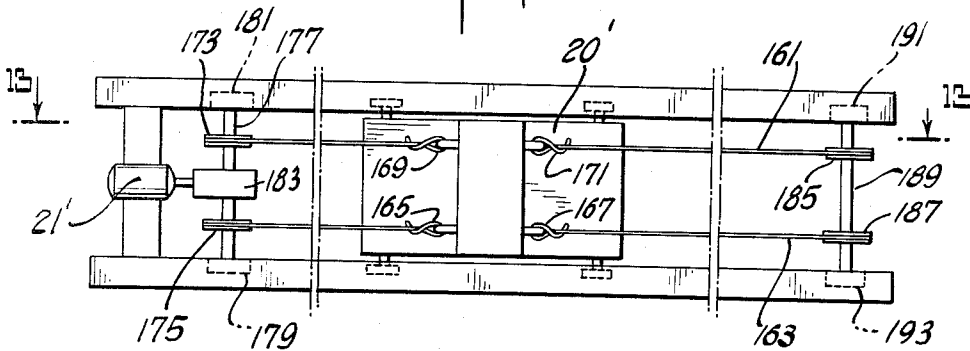


Fig. 14.



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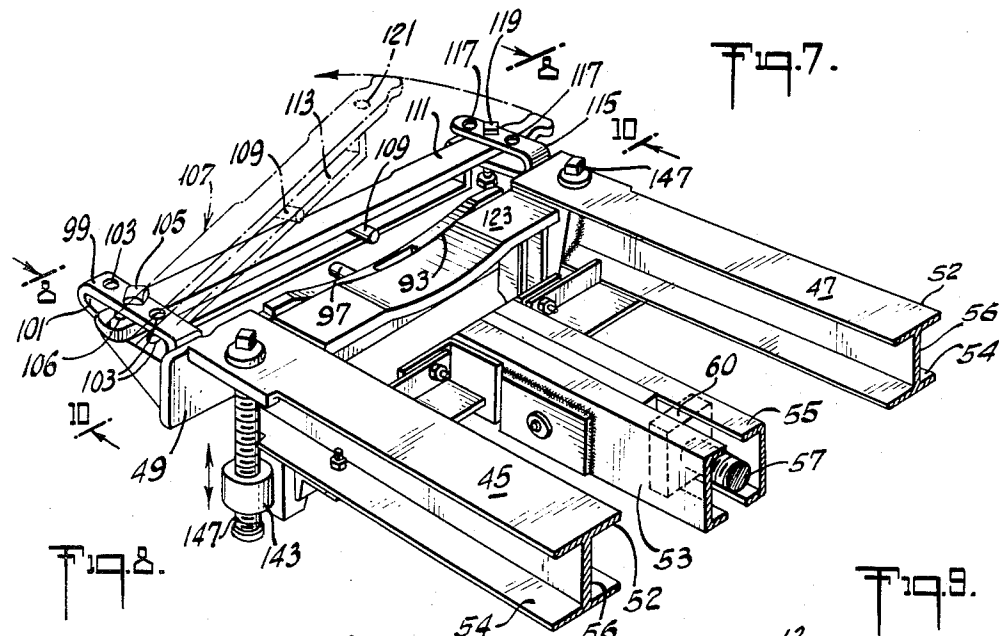
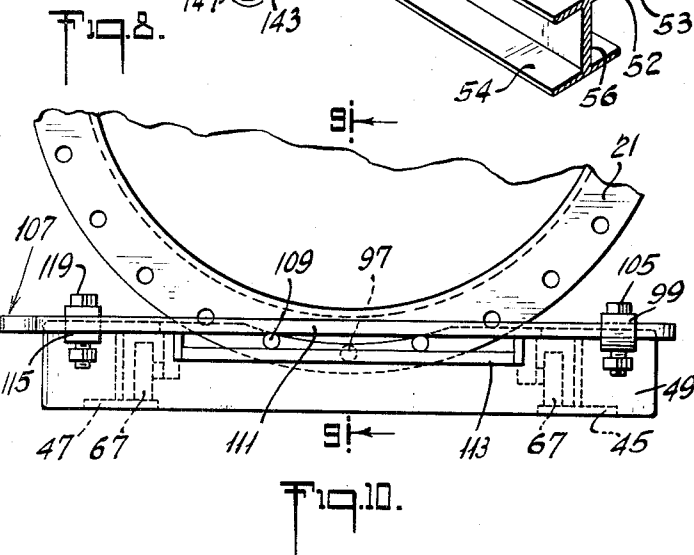
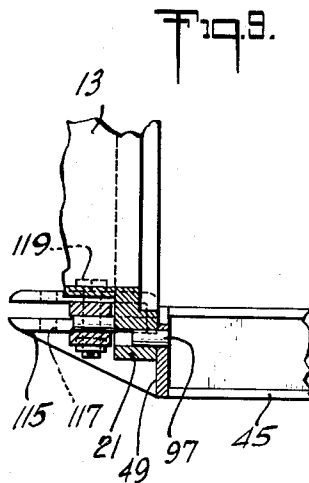
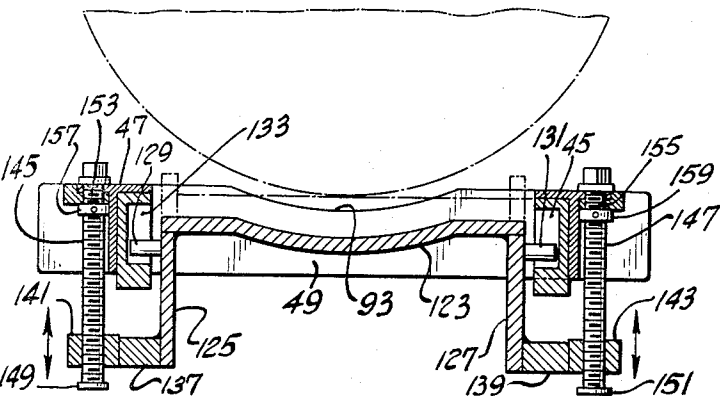
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Fig. 11.

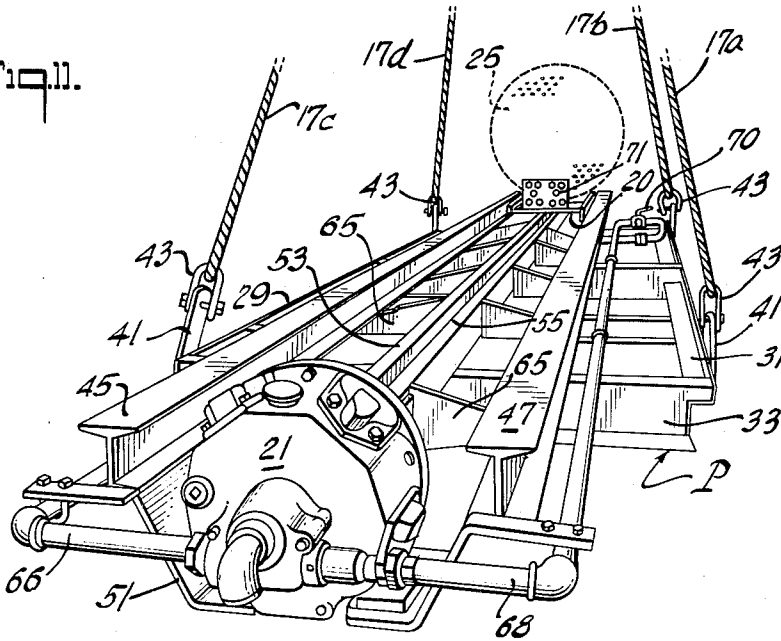
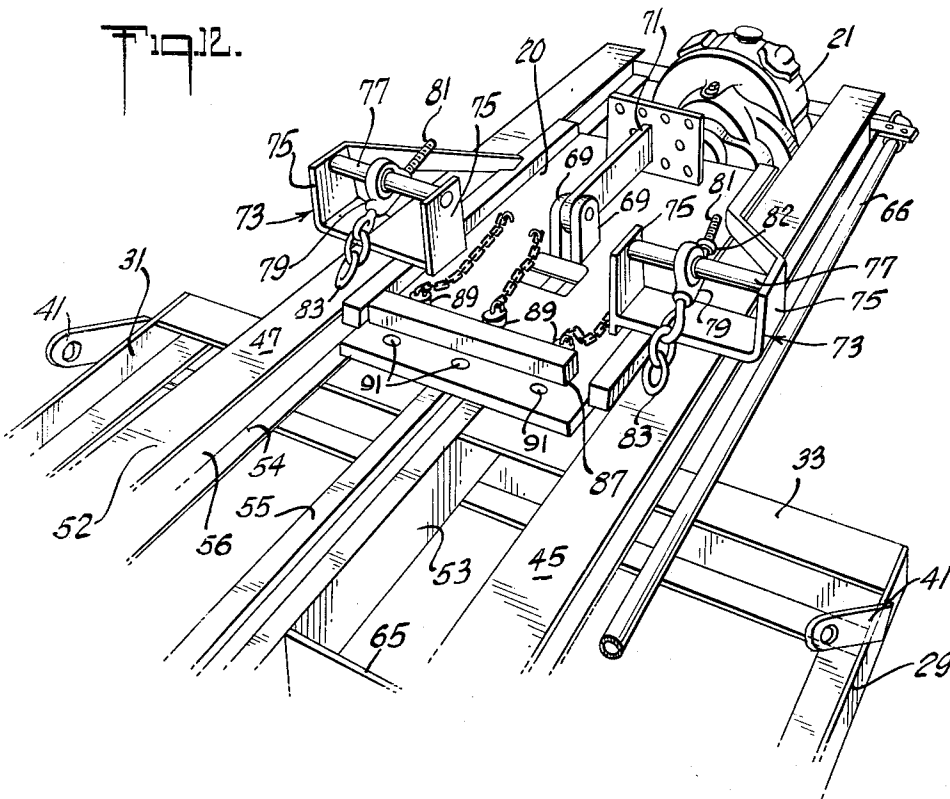


Fig. 12.



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3,239,077 APPARATUS FOR MOVING HEAT EXCHANGER TUBE BUNDLES

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Filed Nov. 21, 1957, Ser. No. 697,825
17 Claims. (Cl. 214—1)

The present invention relates to a novel apparatus for moving a tube bundle out of or into a horizontal heat exchanger shell.

Oil refineries and chemical plants employ many large heat exchangers wherein a cylindrical bundle comprising many metal tubes is located within a cylindrical metal shell, whereby heat exchange may be obtained between a fluid passing through the tubes and another fluid passing around the tubes within the shell. Such heat exchangers are often very large in size, such as 4 feet in diameter and 20 feet long, and may weigh several tons. They may be located near the ground, or elevated as much as 75 feet in the air.

After a heat exchanger has been in use for some time, it is usually necessary to remove the tube bundle from its shell for cleaning and repair. In the past a tube bundle has been removed by employing a large steel scaffolding upon which workmen stand while they jack the tube bundle out of the shell. Sometimes such a scaffolding is a permanent part of the heat exchanger installation; other times it must be built for each tube bundle removal job. In either case, it is expensive and requires a great deal of space which could be used to better advantage for other purposes. Furthermore, much manual labor is required.

Our copending application Serial No. 666,061, filed June 17, 1957 for Method of and Apparatus for Moving Heat Exchanger Tube Bundles, describes removing a tube bundle from a horizontal heat exchanger shell by positioning a portable bundle support or pallet adjacent one end of the shell by suspending it from a crane, holding the pallet firmly in position, and forcing the tube bundle from its shell onto a travelling carriage which moves idly along the pallet. Then the tube bundle and pallet together are moved by the crane to a location where reconditioning is to be done.

The apparatus described in our prior application employs a series of pulleys, and a cable which leads from the tube bundle over the pulleys to a reeling mechanism carried by the crane. The end of the pallet adjacent the heat exchanger shell is held in position by pins which pass through mating holes in the shell flange and in the end of the pallet. When using our prior device it is generally necessary to jack the tube bundle manually from the shell for several inches before it can be received by the carriage of the pallet. Moreover, when returning a tube bundle to a shell with our prior apparatus it is generally necessary to rig a pulley cable so that the cable passes through the shell from rear to front for engaging a tube bundle on a pallet.

The apparatus of our prior application is entirely operable and constituted an important advance in the art of maintaining oil refinery equipment. However, further experience has enabled us to devise advantageous improvements which constitute the subject matter of the present application.

In accordance with the present invention, instead of pulling a tube bundle out with a pulley-mounted cable connected to a motor driven reel on a crane, there is provided as an integral part of the bundle support or pallet a motor mechanism which is operatively connected to and positively drives the travelling carriage, for example by a feed screw or cable drive. Additionally, the apparatus is provided with an improved clamping mechanism on one end for engaging a heat exchanger shell to support the apparatus firmly in position. Another important improvement is the provision of means for connecting the travelling carriage to the tube bundle in such a way as to accomplish the initial movement of the bundle from the shell, without requiring manual jacking. Still another improvement is the provision of a device whereby a bundle may be inserted in a heat exchanger shell by direct pressure of the travelling carriage on the tube bundle.

Further details of the apparatus will be described hereinafter with reference to the accompanying drawings wherein:

FIG. 1 is a schematic side elevational view showing the apparatus of the present invention in use for pulling a tube bundle from a heat exchanger shell;

FIG. 2 is a plan view of the apparatus on a larger scale, as viewed from the line 2—2 in FIG. 1;

FIG. 3 is a bottom view on a still larger scale, showing a part of the apparatus of FIG. 2, parts being broken away and in section;

FIG. 4 is a cross sectional view taken along the line 4—4 in FIG. 3, rotated 180°;

FIG. 5 is an enlarged schematic side elevational view of a part of the apparatus of FIG. 1, showing in more detail the means for clamping the apparatus to a heat exchanger shell, and for connecting the carriage to the tube bundle;

FIG. 6 is a schematic side elevational view similar to FIG. 5, but showing an abutment member pushing against the tube bundle;

FIG. 7 is a perspective view of the front end of the apparatus which is adapted to be positioned adjacent a heat exchanger shell, showing details of clamping mechanism and of mechanism for raising and lowering a cradle;

FIG. 8 is a front end view of the apparatus as viewed from the line 8—8 in FIG. 7;

FIG. 9 is a vertical sectional view taken along the line 9—9 in FIG. 8;

FIG. 10 is a cross sectional view taken along the line 10—10 in FIG. 7;

FIG. 11 is a perspective view on an enlarged scale of the apparatus of the invention approximately as viewed from the left or rear end of the apparatus in FIG. 1, showing the carriage at the front end adjacent a heat exchanger;

FIG. 12 is a perspective view on an enlarged scale of a part of the apparatus as viewed approximately from the right or front end of the apparatus in FIG. 1, showing the carriage in fully retracted position adjacent the driving motor;

FIG. 13 is a schematic longitudinal sectional view taken along the line 13—13 in FIG. 14, showing a different embodiment of mechanism for moving the carriage along the support; and

FIG. 14 is a schematic bottom view of the apparatus of FIG. 13;

Referring to FIG. 1 there are shown two heat exchangers A and B with a tube bundle 11 in the process of being removed from the shell 13 of the upper heat exchanger A. This is being done by a mobile crane C having a boom 15 from the end of which extends a suspension cable 17 fastened to a horizontal pallet or elongated movable frame P which is positioned with its front end 19 adjacent to the flange 21 of the shell. Cable 17 comprises a single main section coupled to four legs 17a, b, c, and d.

A carriage 20 is reciprocally mounted in frame or pallet P between the side members or beams 45 and 47, and is movable lengthwise along the pallet P by means of a motor mechanism 21 integrally mounted on the rear end of the pallet, as will be described more in detail here-

inafter. Carriage 20 is connected to the tube bundle 11 by an elongated tension member such as a chain 23 detachably secured or fastened at one end to the tube or end sheet 25, which rests upon the carriage during the withdrawing operation.

After tube bundle 11 has fully emerged from the heat exchanger shell 13 onto pallet P the crane C then carries the suspended pallet away for reconditioning of the tube bundle.

Referring now to FIG. 2, the pallet P comprises a welded support bed 27 composed of a pair of longitudinal steel channel members 29 and 31 which are spaced apart by four transverse steel braces 33, 35, 37 and 39.

Adjacent each of its four corners the support bed 27 carries an upwardly and inwardly slanting ear 41 carrying a shackle 43 for suspending the frame or pallet P by connection to suspension cable 17 (see FIG. 11 for more detail).

On its upper surface the support bed 27 carries a pair of welded-on longitudinally extending parallel side members in the form of beams 45 and 47 which are slightly longer than a tube bundle, project at both ends beyond the ends of the bed, and are spaced apart by a distance less than the width of the bed. The beams are additionally connected together at their front ends by a transverse plate 49, and at their rear ends by a transverse bracket 51 supporting the motor mechanism 21.

Beams 45 and 47 are shown as I-beams having upper and lower flanges 52 and 54 connected by a web 56. Other equivalent specific constructions also can be used, such as the pipe and track devices of our prior application.

A pair of parallel spaced channel bars 53 and 55 extend lengthwise of the apparatus mid-way between beams 45 and 47, with their channels facing each other to form a housing for a longitudinal feed screw 57 which is journaled in a bearing 59 near the rear end of the pallet, and in a similar bearing 60 (FIG. 7) near the front end of the pallet.

The housing formed by channel irons 53 and 55 is fixed rigidly in position by steel webs 65 welded to the I-beams and to the channels.

At its rear end the feed screw is provided with a coupling 61 which engages the shaft of motor 21 to drive the feed screw, which in turn coacts with a travelling nut 63 extending from carriage 20 down between channel bars 53 and 55 to selectively move the carriage along the side members 45 and 47. Consequently, revolution of the motor in one direction drives the feed screw in a direction to move carriage 20 to the rear, and rotation in the opposite direction moves the carriage forward.

Motor 21 is operated by compressed air supplied alternatively through pipes 66 or 68 for direct or reverse operation, control being effected by a three way valve 70 selectively connecting the pipes to a supply main 72. One suitable motor is the 5 H.P. Denver Gardner 5 cylinder radial type piston motor, model 60287.

The carriage 20 has four wheels 67, which ride upon the lower inside flanges 54 of the I-beams 45 and 47 as the travelling nut 63 on the bottom of the carriage moves along the pallet, so that the major portion of the weight of a tube bundle is accommodated by the I-beams rather than by the feed screw and associated channel members.

On its upper surface the carriage 20 is provided with a pair of up-standing laterally spaced trunnions 69 between which is pivotally mounted a pusher arm 71 which is adapted to be moved through 180° into and out of pushing position for installing a tube bundle in a shell (see FIG. 6). The carriage also is provided with a pair of transversely extending outrigger brackets 73, each of which includes a pair of upstanding ears 75 across which extends a cylindrical bar 77. Mounted on each bar 77 and freely movable thereon, both rotationally and lengthwise, is a socket member 79 having a bore within which is located an eye bolt 81 carrying a nut 82 for adjusting

the bolt. A plurality of chain links 83 extend from the eye bolt for connection to a tube sheet when removing a bundle from a shell. The manner of connection is illustrated schematically in FIG. 5, wherein the free end of the chain is shown connected to a horizontal pin 85 projecting from a radial bore in the tube sheet 25. The second chain is secured to a similar pin on the opposite side of the tube sheet. After the ends have been connected as shown, any slack in the chain is taken up by movement of the nut 82 on the eye bolt 81. Tube bundles of different diameters are readily accommodated by moving the socket members 79 along bars 77.

The carriage 20 also is provided on its upper surface with a transverse bar 87 which rests on the carriage and is adapted to be used alternatively to, or to supplement the chains 83. As shown in FIG. 5, the bar 87 abuts against the rear edge of tube sheet 25 for pulling the tube bundle from the shell. Bar 87 is backed up by a plurality of movable dowel pins 89 which are placed within holes 91 in the bed of the carriage.

When the apparatus is being used to insert a tube bundle into a shell, the bar 87 may also be used by positioning the bar against the front edge of the tube sheet and inserting dowel pins 89 in holes on the opposite side of the bar, as illustrated in FIG. 12.

Details of the clamping mechanism for securing the front end of the frame or pallet to the flange 21 of the heat exchanger shell A are shown best in FIGS. 7 and 9. The transverse tie plate 49 is welded to the I-beams 45 and 47 and has a slightly concave top edge 93 matching the curvature of the heat exchanger. From its front surface a centrally located dowel pin 97 projects forwardly so as to fit within the lowermost bolt hole in flange 21.

From one side of tie plate 49 there extends forwardly a bracket 99 having a long channel 101 and a plurality of longitudinally spaced apertures 103 for receiving a pivot pin 105 which extends vertically down through corresponding apertures and through a slot 106 at one end of a cross bar 107, so that the cross bar is mounted with a sloppy fit for pivotal movement in a horizontal plane. The slot 106 is long and narrow so as also to permit some longitudinal movement of the arm 107, thereby assuring that a second dowel pin 109 carried by the arm 107 will register with a second bolt hole in flange 21 adjacent to the lowermost bolt hole. Dowel pin 109 is welded to the cross arm 107 between an upper major arm section 111 and a lower minor arm section 113.

At its opposite end arm 107 is free to move in and out of a second clevis-like bracket 115 which projects forward from the opposite side of the pallet and is open at its forward end. The upper and lower arms of bracket 115 are provided with a plurality of longitudinally spaced vertical apertures 117 adapted to receive a locking pin 119, which extends downwardly through a pair of apertures and through a bore 121 in cross arm 107.

With the apparatus described, the cross arm is first moved to open position as shown in broken lines in FIG. 7. The end of the pallet is positioned against the front surface of flange 21 with the pin 97 in the lowermost bolt hole and with the cross arm 107 on the rear side of the flange. Then the cross arm 107 is swung to closed position with the second pin 109 fitting within the second bolt hole of flange 21, and the retaining pin 119 is dropped through the appropriate pair of apertures 111 to clamp the front end of the apparatus tightly in position. The described construction makes it possible to apply pallet P to heat exchanger flanges 21 of various thickness, and having various bolt hole spacings.

Adjacent the front end of the pallet P there is provided a concave cradle 123 which is adapted to receive the tube sheet at the rear end of the tube bundle 11 after the latter has been completely withdrawn from the shell. If this cradle were fixed rigidly in position it would not be possible to station the carriage 20 at the extreme front end of the pallet so as to receive the front tube sheet 25

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upon initial movement of the bundle from the shell. Therefore, cradle 123 is mounted for vertical movement up and down at the will of the operator, whereby it may be lowered below the top level of beams 45 and 47 to permit carriage 20 to overlie the cradle. Thereafter, when the carriage has moved rearwardly along the pallet with the front end of the tube bundle, the operator raises the cradle to its uppermost position so that when the rear tube sheet leaves the shell it passes directly onto the cradle without having to drop more than a fraction of an inch at most.

The foregoing operation is accomplished by supporting the cradle 123 between the side beams 45 and 47 on downwardly extending legs 125 and 127, each of which carries a laterally projecting pin 129 and 131 captured in vertical slots 133 and 135. At their lower ends legs 125 and 127 are provided with laterally projecting brackets 137 and 139 terminating in internally threaded bushings 141 and 143. A pair of bolts 145 and 147 pass down through apertures in the top flanges of beams 45 and 47 and are threaded through the bushings 141 and 143, being captured therein by flanges 149 and 151 on the lower ends of the bolts. On their upper ends the bolts 145 and 147 are provided with wrench flats and with flanges which rest upon the upper surfaces of the beams. The shank portions 153 and 155 of the bolts lying within the apertures are unthreaded and freely rotatable therein without longitudinal movement. Longitudinal movement is further prevented by a pair of collars 157 and 159 secured by set screws just below the apertures. With the described structure the cradle 123 is lowered below the tops of beams 45 and 47 by rotating the bolts 145 and 147 in a counter-clockwise direction (as viewed from the top), and the cradle is raised in position by rotating the bolts in a clockwise direction.

An alternative mechanism for moving a carriage 20' is illustrated in FIGS. 13 and 14. Carriage 20' is mounted upon the pallet in the same way as described previously, but instead of employing a feed screw for motivation there is employed a pair of cables 161 and 163 having their ends firmly secured to the carriage at 165, 167, 169 and 171. These cables run over a pair of sheaves 173 and 175 adjacent the rear end of the pallet, which are rigidly mounted on a driven shaft 177 journaled at its ends in bearings 179 and 181. A transfer gear box 183 is mounted on the center of the shaft 177 and establishes an operable connection between a driving motor 21' and the shaft. The cables 161 and 163 are also mounted on a pair of idler sheaves 185 and 187 carried on a shaft 189 which is journaled in bearings 191 and 193 near the front end of the pallet.

The operation of the device shown in FIGS. 13 and 14 is similar to that previously described. However, the cable construction has the advantage over the feed screw of economy and simplicity.

Obviously, many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

We claim:

1. Apparatus for moving a tube bundle out of a horizontal heat exchanger shell comprising, in combination, a portable support including, (a) a pair of parallel horizontally spaced beams, (b) a mobile carriage much shorter than said tube bundle for receiving only a front end portion of said tube bundle, said carriage extending transversely between the beams, having a surface upon which said front end portion rests, and being movable along said beams lengthwise thereof over a distance at least as great as substantially the length of said tube bundle, and (c) means for connecting an end of said support to a heat exchanger shell for maintaining a fixed relationship therewith; a tension member secured to said carriage and engageable with such a tube bundle; and driv-

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ing mechanism mounted on said support, portable as a unit therewith, and operatively connected to said carriage for moving said carriage lengthwise along said beams, whereby a pulling force is transmitted from said driving mechanism through said carriage and said tension member to such a tube bundle.

2. Apparatus in accordance with claim 1, also comprising manual control mechanism operatively connected to said driving mechanism for controlling the starting and stopping of said driving mechanism, said control mechanism being carried by said support at a position adjacent said end such that said control mechanism is accessible to and operable by an operator working at said end.

3. Apparatus for moving a tube bundle out of a horizontal heat exchanger shell comprising, in combination, a portable support including, (a) a pair of parallel horizontally spaced beams, (b) a mobile carriage much shorter than said tube bundle for receiving only a front end portion of said tube bundle, said carriage extending transversely between said beams, having a surface upon which said front end portion rests, and being movable along said beams lengthwise thereof over a distance at least as great as substantially the length of said tube bundle, and (c) means for connecting an end of said support to a heat exchanger shell for maintaining a fixed relationship therewith; an elongated tension member secured at one end to said carriage and engageable at the opposite end with such a tube bundle; and driving mechanism mounted on said support bed, portable as a unit therewith, and operatively connected to said carriage for moving said carriage along said beams, said mechanism comprising a motor, a drive screw operatively connected to said motor and extending lengthwise of said beams, and driven means on said carriage engaging said drive screw so as to be driven thereby, whereby a pulling force is transmitted from said driving mechanism through said carriage and said tension member to such a tube bundle.

4. Apparatus in accordance with claim 3 wherein said mechanism comprises two spaced bearings on said support spaced from one another lengthwise thereof, said drive screw being rotatably mounted in said bearings; and wherein said driven means is a traveling nut fixed on said carriage and engaging said drive screw.

5. Apparatus for moving a tube bundle out of or into a horizontal heat exchanger shell having a flange thereon comprising, a combination, a portable support bed including a pair of parallel spaced beams, said support bed having on one end thereof a clamping device operable to engage a heat exchanger shell, for holding said support bed firmly in position against said shell during movement of a tube bundle out of or into said shell, said clamping device comprising a pair of cooperating clamping members movable toward and away from one another and adapted to clamp onto said flange; a movable carriage for receiving the front end of a tube bundle, said carriage having a surface upon which said front end rests, said carriage lying between said beams and being movable along said beams lengthwise thereof; and mechanism mounted on said support bed, portable as a unit therewith, and operatively connected to said carriage for moving said carriage along said beams.

6. Apparatus in accordance with claim 5 wherein said clamping device comprises a member adjacent the end of said support bed for abutting against the front surface of a flange, said member carrying a pin adapted to fit within a first bolt hole in said flange; and a cooperating member adapted to abut against the rear surface of such a flange, said cooperating member having a pin so located as to enter a second bolt hole in said flange spaced from said first bolt hole.

7. Apparatus in accordance with claim 6 wherein said cooperating member comprises a bracket projecting longitudinally from said support bed, a horizontal bar pivotally mounted adjacent one end thereof on said

bracket, a detent member projecting from said support bed in position to receive the opposite end of said horizontal bar, and means for securing said opposite end to said detent member.

8. Apparatus for moving a tube bundle out of or into a horizontal heat exchanger shell comprising, in combination, a portable support bed including a pair of parallel spaced beams; a movable carriage for receiving the front end of a tube bundle, said carriage having a surface upon which said front end rests, said carriage lying between said beams and being movable along said beams lengthwise thereof; mechanism mounted on said support bed, portable as a unit therewith, and operatively connected to said carriage for moving said carriage along said beams; means for fastening an end of said support bed to a heat exchanger shell; a cradle adjacent said end between said beams; and means securing said cradle to said support bed for movement up and down to move said cradle below the level of said carriage, thereby permitting said carriage to be positioned over said cradle during the initial movement of said tube bundle out of a heat exchanger shell, and thereafter to move said cradle to a higher position for receiving the rear end of said tube bundle.

9. Apparatus in accordance with claim 8 wherein said cradle extends horizontally and carries adjacent the opposite ends thereof a pair of threaded bushings, said apparatus also comprising a pair of bolts extending down through said beams into said bushings and rotatable therein to raise or lower said cradle.

10. Apparatus for moving a tube bundle out of a horizontal heat exchanger shell comprising, in combination, a portable support bed including a pair of parallel spaced beams; a movable carriage for receiving the front end of a tube bundle, said carriage having a surface upon which said front end rests, said carriage lying between said beams and being movable along said beams lengthwise thereof; mechanism mounted on said support bed, portable as a unit therewith, and operatively connected to said carriage for moving said carriage along said beams; and elongated tension means having one end thereof secured to said carriage and adapted to be connected at the opposite end thereof to a tube bundle for pulling said tube bundle from said heat exchanger shell.

11. Apparatus in accordance with claim 10 wherein said elongated tension means comprises a pair of transversely extending mountings spaced laterally from one another on said carriage, and a pair of elongated members each mounted at one end thereof on said mountings and movable laterally thereon, the opposite ends of said members being adapted to engage a tube bundle, and means for adjusting the length of said elongated members.

12. Apparatus in accordance with claim 10 wherein said elongated tension means comprises a pair of transversely extending mountings spaced laterally from one another on said carriage, and a pair of elongated members each mounted at one end thereof on said mountings and movable laterally thereon, the opposite ends of said members being adapted to engage a tube bundle.

13. Apparatus for moving a tube bundle out of or into a horizontal heat exchanger shell comprising, in combination, a portable support bed including a pair of parallel spaced beams; a movable carriage for receiving the front end of a tube bundle, said carriage having a surface upon which said front end rests, said carriage lying

between said beams and being movable along said beams lengthwise thereof said carriage having an upwardly projecting abutment member thereon adapted to engage the tube sheet of a tube bundle for pulling said bundle from or pushing said bundle into a heat exchanger shell; and mechanism mounted on said support bed, portable as a unit therewith, and operatively connected to said carriage for moving said carriage along said beam.

14. Apparatus in accordance with claim 13, also comprising a plurality of dowels, and a plurality of holes in said carriage on both sides of said abutment member for receiving said dowels to reinforce said abutment member.

15. Apparatus in accordance with claim 13 wherein said abutment member is pivotally secured to said carriage for movement into and out of position for engaging such tube bundle.

16. Apparatus for moving a tube bundle out of or into a horizontal heat exchanger shell comprising, in combination, a portable support bed including a pair of parallel spaced beams; a movable carriage for receiving the front end of a tube bundle, said carriage having a surface upon which said front end rests, said carriage lying between said beams and being movable along said beams lengthwise thereof; mechanism mounted on said support bed, portable as a unit therewith, and operatively connected to said carriage for moving said carriage along said beams; a cradle adjacent one end of said support bed between said beams; and mechanism for moving said cradle up and down between said beams to permit said carriage to be positioned above said cradle during the initial movement of a tube bundle from a heat exchanger shell, and thereafter to move said cradle to a higher position for receiving the rear end of a tube bundle.

17. A tube bundle extractor comprising an elongated movable frame having parallel side members, means for suspending said frame to be aligned with the end of a shell containing a tube bundle having end sheets, means for securing one end of said frame to said shell, a carriage reciprocally mounted in said frame between said side members, means on said carriage for detachably securing it to an end sheet of said tube bundle, and means for selectively moving said carriage longitudinally along said side members to withdraw said tube bundle from said shell or to insert it therein.

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GERALD M. FORLENZA, *Primary Examiner.*

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