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(54) IMPROVEMENTS IN OR RELATING TO THE ASSEMBLY OF HEAT EXCHANGERS

(71) We, SOCIETE ANONYME DES USINES CHAUSSON, a company organised under the laws of France, of 35 rue Malakoff, ASNIERES (Hauts de Seine), France do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a new method and machine for mounting water jackets on heat exchanger tube plates provided to constitute for example heating or cooling radiators for vehicles.

It is well-known in the art to fix the water jackets of heat exchangers, comprising a core of tubes, onto the tube plates, by introducing a resilient rubber gasket between the bottom of each water jacket and the top of each tube plate, said gasket being kept under pressure to make it watertight.

For that purpose, use is advantageously made of strips or clips which encircle the sides of the tube plates and water jackets so as to maintain firm pressure between these water jackets and the tube plates on which they are mounted.

Although the positioning of such strips may appear as a simple mechanical operation, when it comes to mass production it has been found very difficult to fit these strips and ensure that a uniform pressure is exerted by the water jacket all round the resilient gasket in the tube plate; also it was difficult to eliminate the risk, when the strips were fixed in place, that the union previously made between the ends of the tubes in the heat exchanger core and the tube plates would be damaged.

The problems to be solved are even greater where the water jackets incorporate attachment parts which protrude from their walls, e.g. tubes and fixing clamps, which are needed to connect water jackets to the fluid circulation in the exchangers. In fact, such protruding attachment parts make it awkward to get at the strip parts, needed to fix each water jacket to each tube plate.

The invention solves the above mentioned problems.

According to the invention there is provided a method of fixing two water jackets or tanks on the tube plates of heat exchangers with tubes fixed in the tube plates, such fixing being carried out, in part at least, by means of fixing strips which must be bent over a peripheral projection on each water jacket, comprising placing the heat exchanger so as to rest on a support having support parts for each of two tube plates, the distance between said support parts corresponding to each tube plate being slightly less than the distance separating said two tube plates, exerting pressure on one of the water jackets to bring the corresponding tube plate against the support parts by making it compress a resilient gasket in base of the tube plate, bending the fixing strips over the projection of the jacket, releasing said jacket and the tube plate in which it is fixed, and exerting a thrust on the other jacket to bring its tube plate against the support parts adjacent thereto, so as to compress in its turn the corresponding resilient gasket before bending the fixing clamps, so that no strain is transmitted to the tubes fixed into the tube plate as a result of the sequential fixing of these two jackets.

The machine for carrying out the above method is characterised in that it comprises two centring plates, between which the core of tubes is located without being squeezed, the length of the centring plates being slightly less than the distance between the two tube plates, two thrust plates one for each of the water jackets, and connected respectively to one of two plates by elastic elements having a modulus of elasticity corresponding to the pressure to be exerted by the jackets to deform a resilient gasket between each

jacket and each tube plate, a set of fixing means connected to each of said plates and encircling said thrust plate and two sliding mechanisms carrying respectively the two plates, these sliding mechanisms being operated one after the other, so that the securing of the two jackets by bending the tongues of the strips is carried out successively, the corresponding tube plate being at each time brought up against the centring plates gripping the core of tubes.

Various other features of the invention are made apparent in the detailed description which follows.

An embodiment of the invention is shown by way of non-limitative example in the attached drawings, wherein:

Figure 1 is an exploded side view of a heat exchanger, showing the operations to be performed by the assembling machine of the invention,

Figure 2 is an exploded view like Figure 1, but turned at right angles to it,

Figure 3 is a very enlarged cross section along line III—III of Figure 1,

Figure 4 is an elevation view showing the main parts of the machine covered by the invention,

Figure 5 is an elevation view corresponding to Figure 4, but turned at right angles to it,

Figure 6 is a plan view, partly in cross section, of the working parts of the machine illustrated in the preceding figures,

Figure 7 is a cross sectional view, partly schematic, of detail A in Figure 6,

Figure 8 is a diagrammatic view, substantially taken along line VII—VII of Figure 6,

Figure 9 is a cross section along line IX—IX of Figure 6,

Figure 10 is a partly diagrammatic cross section, largely following line X—X of Figure 9,

Figure 11 is a partly diagrammatic cross section taken substantially along line XI—XI of Figure 10.

In Figures 1 and 2 we have shown the upper portion of a heat exchanger incorporating tubes 1 fitting into a tube plate 2, at the periphery of which is provided a channel 3 which accepts a watertight gasket 4, which must be kept elastically deformed by the lower edge of peripheral flange 5 of a moulded water jacket 6.

Assembling tube plates with the water jackets must be carried out using metal strips 7, e.g. made of steel, which are positioned on each of the two larger sides of the end plates. In addition, assembling is also carried out using clamps 8 and 9, formed directly on the tube plate on its outer side forming the channel 3; these clamps 8 and 9 are to be bent over shoulders (or bosses) 10 and 11 found on the smaller sides of the water jacket 6. The top of flange 5 of the water jacket forms a flange or bead 12 on each of the larger sides and this shoulder is to be used to support fingers 13 formed from the strips 7.

As shown in Figure 3, each strip 7 has two sides 7*a* and 7*b* bent substantially at a right angle with respect to each other, these sides being lengthened by the fingers 13, which are bent over flange 12 and by fingers 14, which take support on the lower part of the tube plate 2. The fingers 13 and 14 are partly bent until they are parallel, which makes it easy to position the strips when the water jacket is mounted on the tube plate. Moreover, as a result of this arrangement, the fingers 13 are in a pre-fixing position when the other fingers are positioned, which simplifies the fixing operations carried out by the machine as hereinbelow described.

Figures 1 and 2 show a complex water jacket to illustrate the most complicated operations of which the machine is capable. The complexity of the water jacket is due to the fact that it incorporates a filler neck (or flange) 15, the peripheral edge of which extends beyond the shoulder (or boss) 10, partly covering it, a second lateral tube 16 emerging above flange 12 with an extra thickness 16*a* extending to flange 12 and a fixing lug 17 coming above flange 12 and overhanging it for a significant part of its length, the lug 17 incorporating a strengthening piece 17*a* extending as far as flange 12.

The foregoing shows that the existence of a filler neck 15, tube 16 and fixing lug 17 must be taken into account when fixing the jacket in position, using the tongues 13, because obviously these tubes and lugs prevent fixing tools being used perpendicularly to the flange 12.

Because the fixing machine must be able to deal with jackets incorporating tubes as above described or not, it must therefore be readily adaptable, a fact which is explained in the following description.

As regards the strips 7, provided water jacket 6 to be secured does not have tube 16 and reinforcement 17*a*, they can have all their tongues 13 regularly spaced. On the other hand, in the complex situation considered, some of these tongues, in this case the tongues 13_1 and 13_2, marked by the dotted line, are either dispensed with or elevated in relation to the position they occupy in Figure 3.

To ensure uniformity of the pressure exerted by the flange 5 on the gasket 4, the following description shows that the fixing operation performed by the machine is carried out in a single operation for

each of the two water jackets 6 of the exchanger. To facilitate these operations by the machine, lugs 8 formed by the tube plate 2 which must be below the end tube 15 are pre-bent as shown at 8_1 before the jacket is fitted in the tube plate. On the other hand, the lugs 9 which must be secured to boss 11 are left vertical, to allow positioning of jacket 6.

Because the fixing operations described hereafter subject the jacket 6 and the flange 2 to considerable stress, provision is made for tube plates to be supported all along their larger sides and on their smaller sides by supports 18 and 19 (Figure 2) and also by intermediate supports 20 which in the example considered, co-operate with a bent lug 21 on each face 22 and 23 of the heat exchanger, the lug bearing under the smaller side of the tube plate, as shown in Figure 1.

The machine which allows the fixing operations to be carried out is shown generally in Figures 4 and 5. This machine comprises a frame 24 supporting a table 25 which has on its upper part guides (not shown) on which are fixed a lower plate 26 and two adjustable plates 27 and 27*a*, whose position can be adjusted by blocks 28 and 28*a*. Plates 27 and 27*a* each support a jack, 29 and 29*a*, of which only the control rod is depicted and guide rails 30 and 30*a* which can be moved alternately, in the direction of the arrow f_1 and whose travel is limited by adjustable stops 31 and 31*a*. The rods 30 and 30*a* go into plates 32 and 32*a* respectively and are attached to cross pieces 33 and 33*a* respectively, which can be moved on guides 34 and 34*a* respectively by jacks 29 and 29*a*.

Table 25 supports by means of a bracket 35 a pivoting arm 36 to which is connected a plate 37, called the top plate, which can be moved as shown, until it is parallel to lower plate 26, when arm 36 is actuated by jack 38. Arm 36 can also be raised as shown by the dotted lines at 36_1, bringing the top plate 37 to position 37*a*, which releases the upper part of lower plate 26.

Lower plate 26 supports a centring plate 39, which is fixed on it. Likewise, top plate 37 supports a centring plate 39*a*, fixed to its lower side. In length, centring plates 39 and 39*a* are shorter by a few millimetres than the distance between the two tube plates 2 and 2_1, of a heat exchanger and their ends give support to each of the large sides of the tube plates 2 and 2_1 respectively of the exchanger, in which water jackets 6 and 6_1 respectively must be fitted.

When the top plate is lowered as illustrated, the heat exchanger is held in position on lower plate 26, without being squeezed, however, and as shown by the following disclosure, it can be moved slightly lengthwise, for a short distance corresponding to the difference in length between centring plates 39, 39*a* and the distance separating the tube plates 2, 2_1.

For transverse centring of the heat exchanger, before top plate 37 is lowered, lower plate 26 is fitted on both sides of the centring plate 39, with centring devices 40 and 41 respectively, described in more detail by reference to Figure 6.

The slides 33, 33*a* support, by means of plates 42, 42*a*, fixing assemblies 43, 43*a* respectively, similar to each other, so that in the description which follows we describe basically one assembly and apply the same references to the other assembly, followed by index letter " a ".

Each fixing assembly consists of thrust cage (or pressure plate) 44, with the profile of the leading face of this cage substantially corresponding to that of the outer walls of the water jackets 6 and 6_1. These thrust cages are guided as shown in Figures 6 and 9, by rods 48 on which are mounted springs 49, preferably consisting of elastic washers. The force of these springs 49 is determined so that the pressure exerted by each thrust cage 44 on each water jacket causes flange 5 to exert a pressure on gasket 4 of the order of 1 kg/mm along the line of the joint, when corresponding jack 29 is operated.

Each assembly consists of two fixing plates 50, 51 and 50*a*, 51*a* respectively. Fixing plate 50 is continuous in its fixing section 50*a*, which corresponds to that side of the water jacket which is devoid of protuberances. On the other hand, fixing plate 51 has a recess 52 (Figure 11) to encircle fixing clamp 17 of the water jacket 6, 6_1 and lateral tube 16. Moreover, this plate has blocks 53 and 54, whose function is explained in the following disclosure.

The blocks 53, 54 are provided to operate a pivoting shutter (or plate) 55 (Figure 9), hinged on a spindle 56, connected to centring plate 39, carried by bottom plate 26. The shutter 55 is normally held in a slightly pivoted position against a stop 57 by a spring 58. End 55*a* of the shutter 55 makes a fixing tool which allows free access for positioning the exchanger, incorporating the tube plate 2 when the jack 29 is retracted. On the contrary, when the jack moves forward so that fixing plates 50, 51 start to secure fingers 13, blocks 53, 54 act on shutter 55 which is below the fixing clamp 17 of the water jacket to secure strips 13 which are below the fixing clamp 17.

Figure 10 illustrates the foregoing and

also shows that the shutter 55 incorporates a cut out 59 corresponding to the reinforcement 16*a* on the water jacket, under the side tube 16.

In the foregoing, it was explained that the lateral ends of centring plates 39 and 39*a* support the large sides of the tube plates 2 and 2_1; fixing of the fingers 13, and strip 7 must be affected by means of the fixing plates 50, 51, and 50*a*, 51*a* respectively.

We now have to describe how the machine holds the small sides of tube plates 2, 2_1 in position and secures clamps 8 and 9 respectively of each tube plate on the bosses 10 and 11 respectively of the small sides of the water jackets.

On reference to Figure 6, we see that centring assembly 40 has pins 60 and 61 respectively, which are fixed and mark out by their extremities 60*a* and 61*a*, the limits of supports 18, 19 and 20 described in reference to Figure 2. Those parts of pins 60, 61 which form respectively the supports 18, 19 and 20 are, except for the thickness of the strips 13, aligned with the edges of centring plates 39, 39*a* to be separated by slightly less than the distance between the tube plates 2, 2_1.

Centring assembly 41 also has pins 62, 63 like the pins 60, 61 but these pins slide in guides 64 and 65 respectively, and are normally separated from the tube plates by a spring 66, interposed between the guide and a head 62*a* and 63*a*, respectively, of these pins. The pins 62, 63 are moved against the action of their springs 66 when top plate 37 moves to the position depicted in Figures 4 and 5, through the action of cams 67 supported by this plate, cams which present a slope acting on heads 62*a*, 63*a* respectively.

Figures 6 and 7 show that the extremity such as 60*a* of pins 60, 61 and 62, 63 present a support area 68, encasing the small side of the tube plate as far as the feet of clamps 8 and 9 respectively.

In order to secure clamps 8 and 9 of the tube plates, with the exception of clamps 8 which are under end tube 15, centring assemblies 40 and 41 have at their ends grippers 69 pivotally connected to rods 70, 71, themselves pivotally connected to fixed spindles 72, 73. Each rod 70 has a lengthened aperture 74 so that it can be pivotally connected to the spindle 72.

The securing grippers 69 are normally separated from the tube plate extremities by thrust springs 75 and these grippers have a roller 76 at the end facing that forming the fixing part. The rollers 76 are controlled by cams 77, mounted so as to be adjustable on arms 78, protruding sideways from fixing plates 50, 51 or more exactly, from the support connecting them to plates 42 and 42*a* respectively, fixed to the slides 33, 33*a*.

When cams 77 are not acting on rollers 76, spring 75 pushes the grippers 69 in the direction of arrow f_2 and consequently these are not only separated from the tube plate clamps but are slightly pivoted, the rod 70 taking support from one end of lengthened opening 74. Cross bars 78 support adjustable stops 80, which take support on the grippers 69 on completion of the fixing operation.

As regards clamps 8 of the tube plate 2 under protruding terminal tube 15, the plate 50 supports a cage 81 containing two spindles 82 to pivotally connect grippers 83, each of which has a "stud" 84 engaging in a cam forming curved groove 85 of a fixed guide 86 carried by centring assembly 40. The position of the cage 81 is adjustable by a stop 87. The ends of the grippers 83 form fixing bearings 83*a*.

When the jack 29 is retracted, the studs 84 of each gripper are in the position outlined at 84*a*. When jack 29 closes up, plate 42 moves forward and consequently the studs 84 enter the grooves 85, whose openings 85*a* are widened out. The first section of the grooves 85 is curved, which forces the studs and consequently the grippers 83 to separate. In this way the ends 83*a* of grippers pass over the protruding tube 15. Then grooves 85 approach each other, causing the grippers to close behind tube 15 until they occupy the position illustrated in Figure 8. At the end of this operation, ends 83*a* rest on clamps 8 of the tube plate 2 and fix them on the water jacket.

Apart from the foregoing, the top plate 37 has centring blocks 88, which protrude from its underside and engage between centring blocks 89 in centring assemblies 40 and 41 as to ensure that the various devices above described are accurately positioned to interact with each other.

In order to secure the two water jackets 6, 6_1 in the tube plates 2, 2_1 with the help of the machine above described, proceed as follows:

First bend slightly by hand the clamps 8 of the tube plate 2 being under the protruding tube 15. This procedure is useless as regards the clamps 8 of the tube plate 2_2 which does not have protruding tubes. Water jacket 6 is engaged in the tube plate 2 and the same is done with regard to the water jacket 6_1 and tube plate 2_1. Next fit strips 7 on the larger sides of the tube plates 2, 2_1. Having prepared the heat exchanger in this way, it is placed in the machine whose top plate 37 is raised by the jack 38. When it is positioned, the heat exchanger is

placed horizontally on the centring plate 39, whose side ends are then very close to the tube plates 2 and 2_1, with however touching none of them or touching only one of them.

The heat exchanger is introduced so that one face, e.g. face 23 (Figure 6), comes into contact with the pins 60, 61 whose supports 18, 19 and 20 are thus correctly positioned in relation to the tube plates 2 and 2_1. After lowering the plate 37, the jack 29 is operated without operating the jack 29*a*. In this way, plate 42 is moved towards the water jacket 6, which causes the grippers 83 to start moving, as explained in the foregoing.

After a degree of movement by plate 42, the thrust cage 44 is applied to the water jacket 6, which first of all has the effect of moving the tube plate 2 and the whole heat exchanger slightly in direction of arrow f_3. The strips 7 and tube plate 2 are thus applied respectively against the edges of centring plates 39 and 39*a* and against supports 18, 19 and 20. In this way no force is exerted on tubes 1 of the exchanger, which are fixed in the tube plate 2. As the plate 42 continues its movement, it compresses the springs 49, the strength of which is selected to define the pressure which must be exerted by the flange of the water jacket 6 on the gasket 4 in the tube plate 2.

During this latter movement, which corresponds to the compression of the springs 49, the grippers 83 are drawn close together and the same happens with the securing gripper 69, whose roller 76 follows the inclined plane of cam 77. The securing gripper is thus moved in the opposite direction to the arrow f_2, which causes the clamps 9 of the tube plate 2 to bend at about 45° over boss 11 of the water jacket 6. On completion of forward movement of the plate 42, a movement limited by the stops 31 (Figure 4), the fixing plates 50, 51 secure the tongues 13 of the strips 7 on projection 12 of the larger sides of the flange 5 of the water jacket. At the same time, fixing ends 83*a* of the grippers 83 secure the clamps 8, and the stop 80 pushes the securing gripper 69 which is already in contact with the clamps 9 of the tube plate to bend them at 45° and, consequently these clamps are then bent at 90° on the boss 11 in the same way as the tongue 13 of the strips 7. The jack 29 is then reversed so that fixing plates 50, 51 release strips 7. The same applies to securing gripper 69, which is first released by the stop 80, then moved in the direction of arrow f_2, when cam 77 moves back.

Finally, in its turn the thrust cage 44 releases the water jacket 6 which has been mounted on the tube plate 2 and in the same way grippers 83 are brought back to their original position. Next, the jack 29*a* is operated, so that the plate 42*a* moves fixing plates 50*a*, 51*a* towards the tube plate 2_1 and water jacket 6_1. When the cage 44*a* (Figure 4) comes in contact with water jacket 6_1, the whole heat exchanger is first moved so that its tube plate 2_1 rests against corresponding supports 18, 19 and 20 and strips 7 set in position bear against centring plates 39, 39*a*.

Next, the actual securing operations are carried out on the jacket 6_1, exactly as described in the foregoing, except that the clamps 8 and 9 of the tube plate 2_1 are bent to 90° by securing grippers 69 because, so far as concerns the water jacket 6_1, there are no tubes like the tube 15.

The invention is not restricted to the embodiment depicted and described in detail, because it can be modified in various ways without departing from its scope. In particular, when the water jackets do not incorporate protruding parts like the clamp 17 and tubes 15 and 16, the machine is simplified in consequence; the fixing of teeth 13 and strips 7 and clamps 8, 9 of the tube plates is then achieved by fixing plates 50, 51 then 50*a*, 51*a* alone and fixing grippers 69 operated from these plates.

WHAT WE CLAIM IS:—

1. A method of fixing two water jackets or tanks on the tube plates of heat exchangers with tubes fixed in the tube plates, such fixing being carried out, in part at least, by means of fixing strips which must be bent over a peripheral projection on each water jacket, comprising placing the heat exchanger so as to rest on a support having support parts for each of two tube plates, the distance between said support parts corresponding to each tube plate being slightly less than the distance separating said two tube plates, exerting pressure on one of the water jackets to bring the corresponding tube plate against the support parts by making it compress a resilient gasket in base of the tube plate, bending the fixing strips over the projection of the jacket, releasing said jacket and the tube plate in which it is fixed, and exerting a thrust on the other jacket to bring its tube plate against the support parts adjacent thereto, so as to compress in its turn the corresponding resilient gasket before bending the fixing clamps, so that no strain is transmitted to the tubes fixed into the tube plate as a result of the sequential fixing of these two jackets.

2. A machine for mounting two water jackets on the two tube plates of a heat exchanger incorporating a core of tubes fixed to the tube plates, in which fixing strips having tongues connect the tube plates to their respective water jackets, comprising two centring plates between which the core of tubes is located without being squeezed, the length of the centring plates being slightly less than the distance between the two tube plates, two thrust plates one for each of the water jackets and connected respectively to one of two plates by elastic elements having a modulus of elasticity corresponding to the pressure to be exerted by the jackets to deform a resilient gasket between each jacket and each tube plate, a set of fixing means connected to each of said plates and encircling said thrust plate and two sliding mechanisms carrying respectively the two plates, these sliding mechanisms being operated one after the other, so that the securing of the two jackets by bending the tongues of the strips is carried out successively, the corresponding tube plate being at each time brought up against the centring plates gripping the core of tubes.

3. A machine as claimed in claim 2, wherein one of the centring plates consists of a lower plate mounted on a table which also supports the plates and the driving mechanisms which operate them successively, said mechanisms consisting of adjustable jacks of limited travel, the second plate consisting of an upper movable plate, operated by a control device, so that this upper plate is raised to disengage the lower plate, when the heat exchanger is placed in position and withdrawn.

4. A machine as claimed in claim 1 or 2, wherein the lower centring plate incorporates two centring assemblies on each of its larger sides, one of the centring assemblies comprising fixed pins forming, at their extremities, supports for the smaller sides of each tube plate and the other centring assembly comprising movable pins which also provide supports for the smaller sides of the tube plates, said movable pins being connected to springs which tend to disengage them from a position for which their supports are opposite the tube plates and cams carried by the upper plate controlling the movement of said movable pins during the movement of this upper plate, bringing it into contact with the core of tubes of the heat exchanger.

5. A machine as claimed in any one of claims 2 to 4, wherein the supports formed by the fixed pins and the movable pins are arranged so as to be practically aligned with the edges of the centring plates providing support to the respective heat exchanger tube plates so that said tube plates only come into contact successively with a fixed pin and a movable pin when the strip connecting the tube plate to the jacket is in contact with the corresponding edges of the centring plates.

6. A machine as claimed in any one of claims 2 to 5, further comprising fixing grippers connected to some at least of the side faces of the centring assemblies, cams connected to fixing blades operating said fixing grippers in a direction substantially perpendicular to the smaller sides of the tube plate and a bearing stop also connected to the fixing blade moving, at the end of travel of said fixing blades, said grippers in a direction perpendicular to the plane of the tube plates, so that fixing clamps provided on the smaller sides of the tube plate are first bent substantially to 45° and then bent fully to about 90° in relation to their original position.

7. A machine as claimed in any one of claims 2 to 6, wherein the fixing grippers are connected to the centring assemblies by sets of two rods, substantially parallel to each other and pivotally connected to each fixing gripper and to an adjacent part of the centring assembly, one of said two rods having a lengthened aperture at the level of one of its connections to allow movement of the fixing gripper in a direction perpendicular to the plane of the tube plate.

8. A machine as claimed in any one of claims 2 to 7, further comprising a set of two articulated grippers, opposite at least one of the smaller sides of the tube plates covered by a tube protruding from the water jacket, said set of two articulated grippers being connected to the plate moved by said mechanism, each of the grippers having a guide stud engaged in a curved groove, so that the grippers are open during the movement of the mechanism to pass round the protruding tube to form a fixing device for the clamps to be secured on the water jacket below said protruding tube.

9. A machine as claimed in any one of claims 2 to 8, wherein one at least of the fixing blades has a recess corresponding to attachments laterally protruding from the wall of one at least of the water jackets, blocks being provided on both sides of the recess to come into contact with a pivoting shutter situated below said protruding attachments, so that the end of said pivoting shutter bends the tongues of the strips which are below said protruding attachments to secure them.

10. A machine as claimed in any one of claims 2 to 9, wherein the pivoting shutter controlled by the blocks of the

recess is connected to a resilient element working in the direction in which this shutter is moved away from the position corresponding to bending of the tongues of the strips surrounding the tube plates and water jacket.

11. A machine as claimed in any one of claims 2 to 10, wherein the centring plates and the plates supporting the fixing blades and the thrust plates are movable, the mechanisms in the form of jacks being themselves connected to the table which supports them by adjustable components on said table, so the machine can be fitted successively with different sets of centring plates and parts for securing water jackets onto the tube plates of heat exchangers of several dimensions and configurations.

12. A machine for assembling heat exchangers, substantially as described herein with reference to the accompanying drawing.

13. A method as claimed in claim 1, substantially as hereinbefore described.

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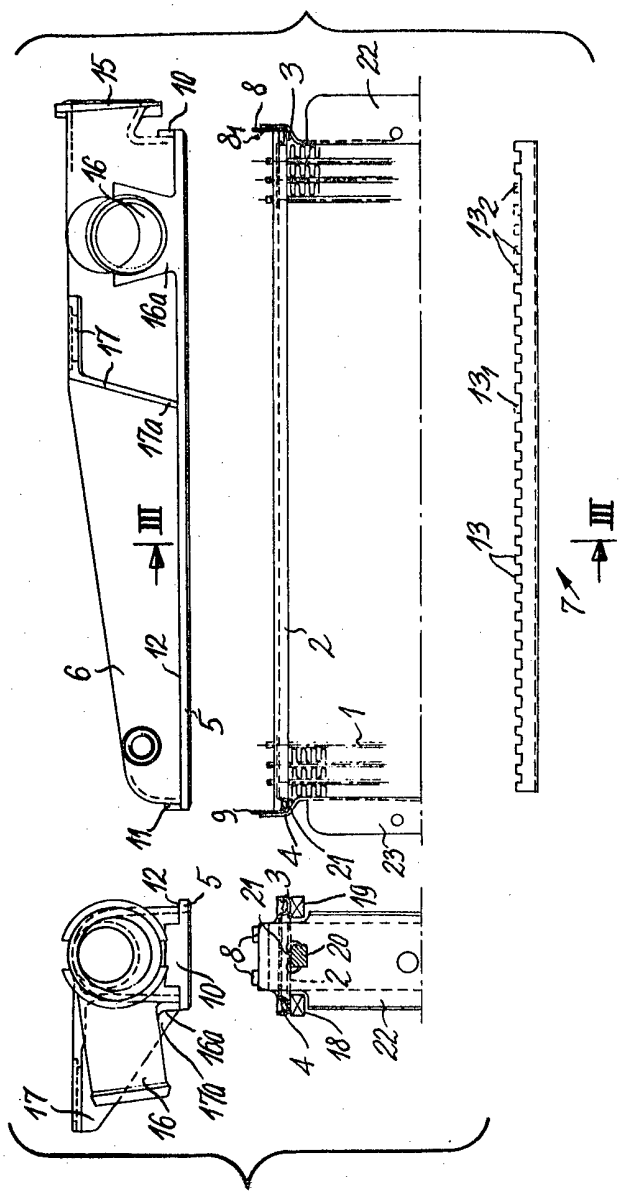

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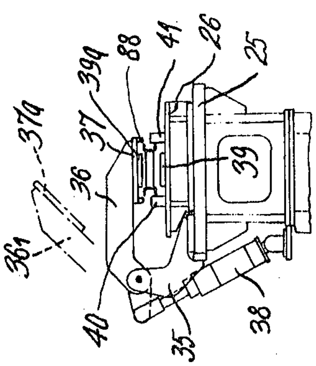

Fig.5

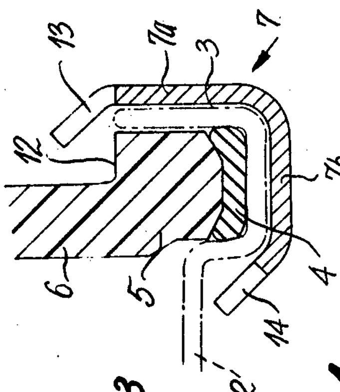

Fig.3

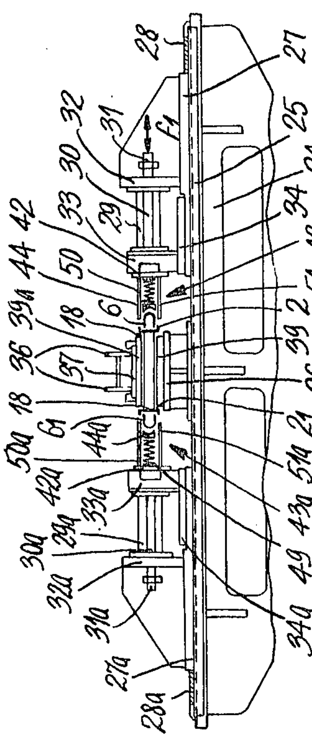

Fig.4

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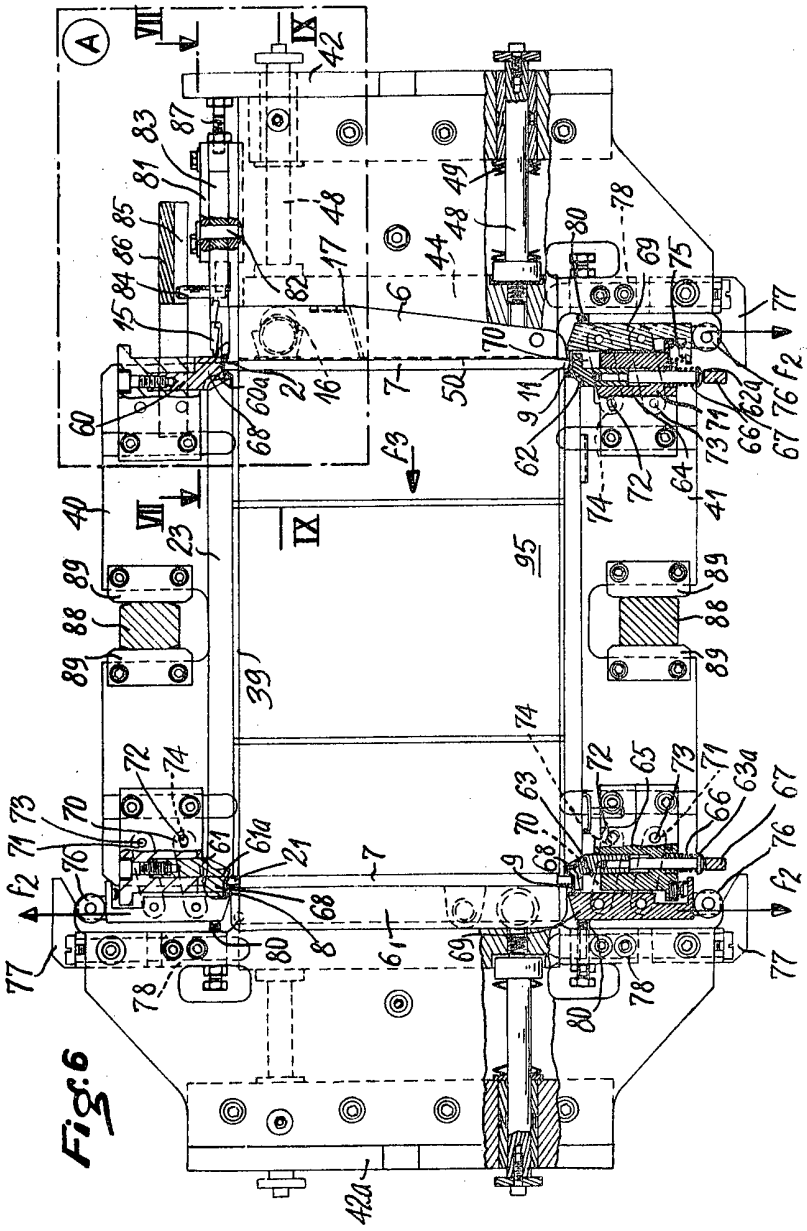

Fig.6

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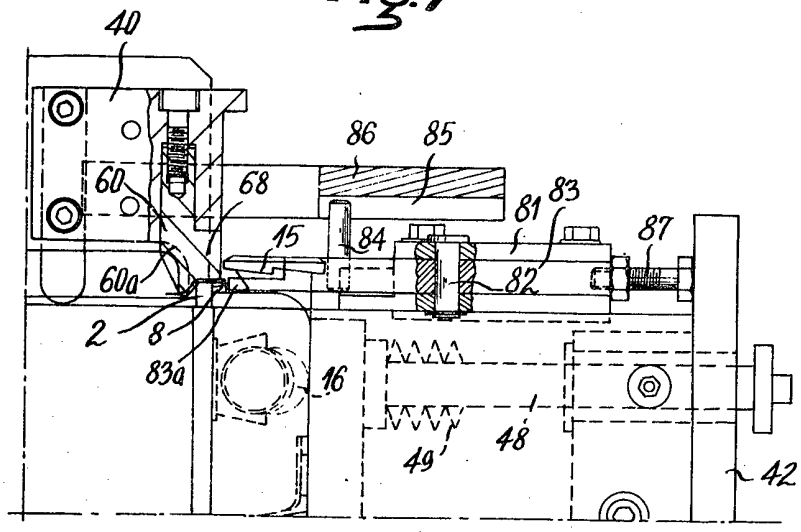
Fig:7



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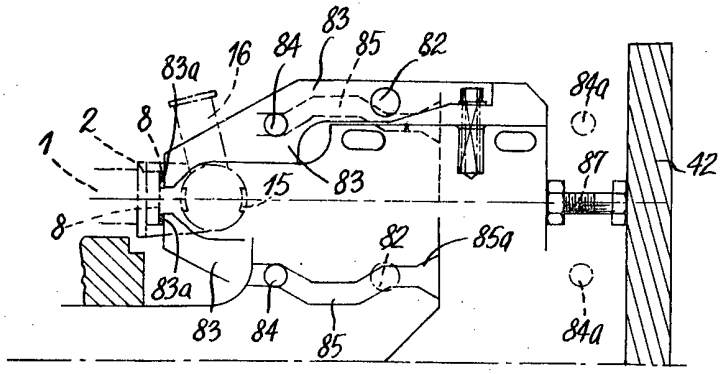

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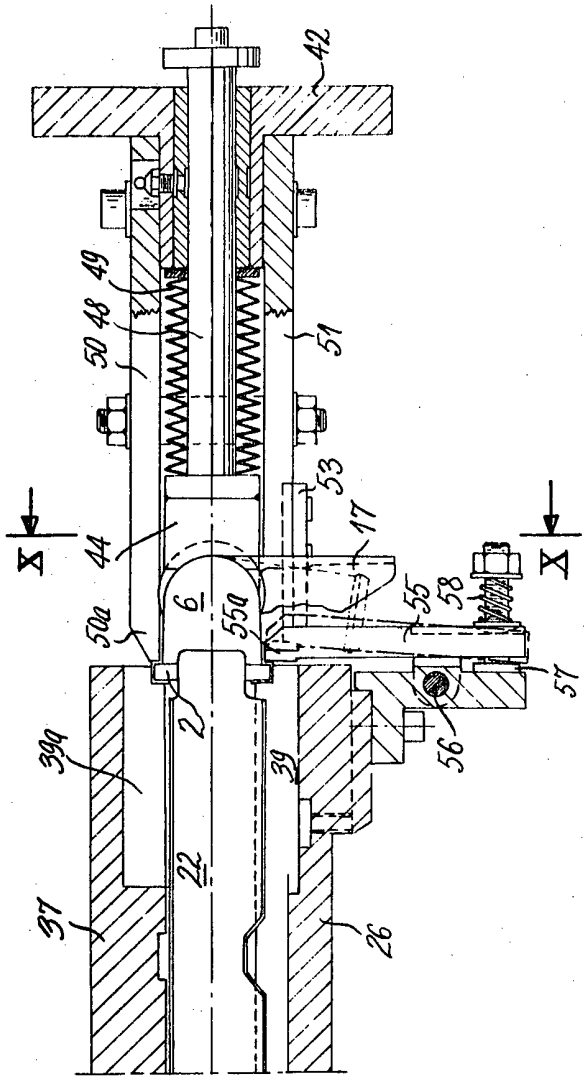
Fig.9



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