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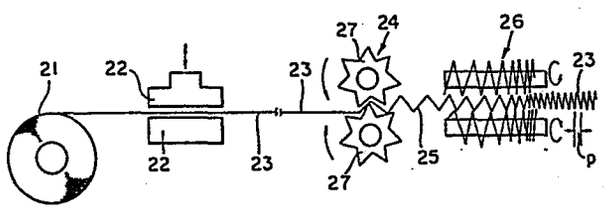
(54) Apparatus for forming corrugated fins for heat exchangers.

(57) An apparatus for forming a corrugated fin for a heat exchanger, which comprises a pair of confronted gear rolls (24, 5) for roughly forming a strip metal plate (23) into a wavy shape, and a pair of screw shafts (30) rotatably disposed in parallel with a feeding passage of the roughly formed strip metal plate and on opposite sides of the feeding passage, the respective screw shafts being provided with helical blades (31) on the outer peripheries thereof, the blades serving to compressively form the strip metal plate into a wavy shape having a predetermined fin pitch, by being brought into contact with valleylike portions of the strip metal plate, and an apparatus for forming a corrugated fin for a heat exchanger, in which there are further disposed tape-attaching mechanisms (55) for adhesively attaching tapes to opposite sides of the corrugated fin.



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The present invention relates to an apparatus for forming a corrugated fin for a heat exchanger which can contribute suitably to miniaturization and weight lightening of the heat exchanger.

In the case of the heat exchanger in which a heat exchange is carried out between two fluids inside and outside a pipe, it is prevalent to dispose fins on the side of the fluid having a less heat transfer with the intention of improving heat transfer performance. Thus, in a condenser or an evaporator in an automotive air conditioner, or in a radiator or the like, the heat exchanger having a corrugated fin as shown in Figure 1 attached hereto is now employed.

Such a corrugated fin type heat exchanger can be manufactured by bending, in a hairpin style, a heat transfer pipe 2 equipped with union joints 1, at both the ends thereof, for connecting itself to other pipes; inserting corrugated fins 3 between straight portions of the heat transfer pipe 2; and securing the fins 3 to the pipe 2 with the aid of brazing.

Further, in place of the simply flat corrugated fin, other types of corrugated fin are suggested: One example is a louver-having corrugated fin 5 in which louvers 4 are formed in the flat portions thereof for the purpose of improving heat transfer performance, as shown in Figure 2,

and another example is a needle corrugated fin 6 in which the thin metal plate thereof is configured in the form of a ladder for the sake of, for example, decreasing a pressure loss on the air side, as shown in Figure 3 (Japanese Utility Model Application No. 71462/1982 and Japanese Patent Application No. 35653/1982).

The aforesaid louver-having corrugated fin 5 can be manufactured by means of a system as shown in Figure 4. That is to say, a strip metal plate 10 is fed to between a pair of confronted gear rolls 11, where a cutting of the louvers and a rough formation of a wavy shape are accomplished by a cutting means provided on tooth surfaces of each gear roll 11 and by a forming mechanism, respectively. Next, the wavy fin 12 is suppressed on the tops thereof by a suppressive spring plate 14 equipped with a pressure-adjusting member 13 in order to regulate a feed of the fin 12, thereby obtaining a desired pitch thereof. The thus prepared fin 12 is cut into a predetermined length, thereby manufacturing desired fin products.

On the other hand, the aforesaid needle corrugated fin 6 has a less stiffness in the direction of a height h thereof than the louver-having corrugated fin 6. Further, in the needle corrugated fin, it is necessary that the metal plate is closely corrugated narrowing each fin pitch P and that finishing is made with high accuracy, when its

high performance is required. For these reasons, it is difficult to employ the conventional apparatus for manufacturing louver-having corrugated fins as shown in Figure 4, for the formation of the needle corrugated fin, without any modification. Accordingly, an improvement in the apparatus has been desired by which the formation of the fin can be carried out efficiently.

In view of such a desire, the present invention has now been accomplished, and its object is to provide an apparatus for forming needle corrugated fins with high accuracy and at a high speed. The apparatus of the present invention for achieving the above-mentioned object comprises a pair of confronted gear rolls for roughly forming, into a wavy shape, a strip metal plate in which a group of ladderlike or netlike needle fin units is previously formed, and a pair of screw shafts rotatably disposed in parallel with a feeding passage of the roughly formed strip metal plate and on opposite sides of the feeding passage, the screw shafts being provided with helical blades on outer peripheries thereof, the pitch of the blades being constituted so as to gradually approach to a predetermined fin pitch toward front edges of the screw shafts, the blades serving to compressively form the strip metal plate into a wavy shape by being brought into contact with valleylike portions of the strip metal plate.

Another object of the present invention is to provide an apparatus for forming a corrugated fin to which reinforcing tapes are attached.

Since being made of a thin metal plate of 0.2 mm or less in thickness, the flat corrugated fin 3 and the louver-having corrugated fin 5 are extremely low in stiffness and tend to be easily bent and distorted. Further, when the corrugated fins which have been thus formed are stocked overlapping each other, the curved portions 7 of the corrugated fins get disadvantageously into between flat portions 8 thereof. In other words, while being stocked, the so-called entangling state will take place, which fact will make troublesome handling such as their conveyance to a farther process.

Also with regard to the needle corrugated fin 6, the thin metal plate of approximately 0.3 mm in thickness is used, and the needle fins 9 of approximately 0.3 mm in diameter are punched out, thereby obtaining a ladderlike shape. Therefore, its stiffness is also disadvantageously at a low level, as in the case of the above louver-having corrugated fin.

Because of such a low stiffness, it is hard to mechanize or automate an insertion of the fins into between straight portions of the heat transfer pipe when the fins are joined to the heat transfer pipe. Therefore, it is

inevitable that the above operation is carried out by hands, and this is an only unautomatic process out of the processes of manufacturing heat exchangers, which unautomatic process stands in the way of the improvement in the whole production efficiency. Moreover, it takes a long period of time to assemble the heat exchangers owing to the hand operation above, which leads to an increase in manufacturing cost. And such a long-time successive operation will render workers very tired, and after the insertion of the fins, their concentration on the work of uniformizing the fin pitch will drop. Additionally, when the corrugated fins are taken out after storage and if they are under the entangling state mentioned above, the fin pitch thereof will be disordered, which fact will bring about deteriorations in heat transfer performance and in quality.

The decline in the stiffness of the fins has been investigated by the inventors of the present case, and it has been found that its main cause is a prolongation of the fin pitch, i.e. an elongation of a wave length of each formed corrugation, i.e. a drop in wave height thereof caused by the above elongation.

In view of such a result of the above investigation, the present invention has now been accomplished, and its object is to provide an apparatus for forming a corrugated fin having supporting means by which the fin pitch of

the corrugated fin can be retained and their stiffness can be enhanced without altering a configuration of the fin and a thickness of the used metal plate. The apparatus of the present invention for achieving the above-mentioned object further includes a device for attaching tapes to free areas of the corrugated fin which will be joined to the heat transfer pipe with a predetermined fin pitch, so as to retain the fin pitch.

Other objects and features of the present invention will be understood from the following description with reference to the accompanying drawings, in which:

Figure 1 is an elevational view of a corrugated fin type heat exchanger, with its central portion omitted;

Figure 2 is a partial perspective view of a louver-having corrugated fin type heat exchanger;

Figure 3 is a partial perspective view of a needle corrugated fin type heat exchanger;

Figure 4 is a schematic layout view of a conventional apparatus for forming the louver-having corrugated fins;

Figure 5 is a schematic layout view regarding one embodiment of an apparatus for forming corrugated fins according to the present invention; Figure 5 (a) is an elevational view and Figure 6 (b) is a plan view;

Figures 6 to 8 show a compressive-formation step; Figure 6 is a plan view, Figure 7 is an elevational view,

and Figure 8 is a right-side view;

Figure 9 is an elevational view showing another embodiment of a fin formed by the apparatus according to the present invention;

Figure 10 is a plan view showing the apparatus according to the present invention in which there is equipped with a device for attaching fin pitch-supporting tapes to the corrugated fin;

Figure 11 is an enlarged sectional view taken along line I - I in Figure 10;

Figure 12 is a partial perspective view of a needle corrugated fin having the fin pitch-supporting tapes; and

Figure 13 is a similar partial perspective view of a louver-having corrugated fin.

The apparatus for forming the needle corrugated fins according to the present invention comprises a pair of upper-side and lower-side molds 22 for punching holes into a strip metal plate 21 to form it into a ladderlike shape, thereby obtaining a primarily processed strip metal plate 23 having a group of needle fin units, as shown in Figure 5 (a); a rough forming section 24 for roughly forming the primarily processed strip metal plate 23 into a wavy shape; and a compressive forming section 26 for compressively forming the roughly formed, i.e. secondarily processed strip metal plate 25 so that it

may have a predetermined closer fin pitch P, as shown in Figure 5 (b).

In the rough forming section 24, there is disposed, on the left and right sides in a horizontal plane when viewed from plan, a pair of gear rolls 27 which can be rotated at a constant speed while engaged with each other, and the primarily processed ladderlike strip metal plate 23 is fed to between this pair of gear rolls 27 in order to form it into the wavy shape. As the pair of gear rolls 27 to be used, rolls are used which are slightly longer in the axial direction thereof than a width of the strip metal plate 21, i.e. a height h of the fin joined to a heat transfer pipe. Further, seeing that the strip metal plate 21 is roughly formed into the wavy shape only at the opposite edges in the width direction thereof, the gear rolls 27 may be employed each of which has a thin-wall gear structure only at the opposite ends thereof and includes no gear structure on the central portion thereof. Furthermore, as for teeth of the rolls 27, tooth tops thereof and tooth bottoms therebetween are rounded in the form of arc which is suitable for corrugation.

The above-mentioned compressive forming section 26 is illustrated in Figures 6, 7 and 8. As shown in the respective drawings, a pair of secrew shafts 30 is disposed in parallel with a feeding passage of the secondarily

processed strip metal plate 25 which is provided on a bed 28 and on the opposite sides of the above feeding passage, and bearing-supporting plates 29 are disposed on right and left sides of the screw shafts 30, when viewed from plan, across the above feeding passage. In this case, the screw shafts 30 are rotatably mounted on bearings (not shown) in the bearing-supporting plate 29.

The above bearings may be constituted movably inside the bearing-supporting plate 29 so as to adjust the space between the respective screw shafts 30.

Each screw shaft 30 is provided with blades 31 on the outer periphery thereof. These blades 31 serve to compressively form the roughly wavily formed, i.e. secondarily processed strip metal plate 25 (hereinafter also referred to as the wavy metal plate) into the fin structure having a predetermined pitch by a contact of the outer peripheral tops of the blades with valleylike portions of the metal plate 25 and by a forward movement of the metal plate 25 with the aid of the rotation of the screw shafts 30. For this service, the blades are helically constituted so that intervals therebetween may become gradually narrow toward the front end of each screw shaft 30 and so that the pitch of the blades in the vicinity of the front end thereof may be equal to a predetermined pitch of the fin.

The above-mentioned screw shafts 30 are adapted to be

rotated reversely to each other. Therefore, helical directions of the blades 31 on the respective screw shafts 30 are reverse to each other, and the wavy metal plate 25 can thus be forward moved in the feeding direction by means of the rotation of the screw shafts 30. In order to cause this rotation, a follower 32 which engages with a pinion of an electric motor (not shown) is fixed to a stretchable shaft 33. By rotating the follower 32, either screw shaft 30 can be rotated via a bevel gear 34 at the other end of the stretchable shaft 33 and another bevel gear 35 at an end of the screw shaft 30. Further, a transmission gear 36 at the other end of the above screw shaft 30 rotates a gear 39 fixed at an end of the other screw 30 via intermediate gears 37 and 38. In this way, both the screw shafts 30 can be rotated in directions reverse to each other and at an equal speed. In this case, the disposition of the stretchable shaft 33 and the intermediate gears 37 and 38 permits the screw shafts 30 to be moved in parallel for the purpose of adjusting the space therebetween by sliding the screw shaft 30, while the engagement between the bevel gears 34 and 35 is maintained and while the transmission gear 36 and the gear 39 are in contact with the intermediate gears 37 and 38.

Further, although not being shown in any drawings, the gear rolls 27 for the rough formation and the screw

shafts 30 are connected to each other so that they may be rotated at a constant rotational ratio. For example, when the number of the teeth on each gear roll 27 is taken as n, the rotational frequency of the gear roll 27 is set to 1/n of that of the follower 32.

The bed 28 is provided with a base stand 40 for supporting the wavy metal plate 5, on the lower side thereof, which is being fed to between the screw shafts 30. The base stand 40 includes a cylindrical feeding guide 41 having an enlarged inlet on the rear side of the compressive forming section 26, and a discharge guide 42 on the front side thereof. Additionally, reference numeral 44 represents a counter for counting the rotational frequency of the screw shafts 30.

The formation will be carried out by means of the thus constituted apparatus according to the present invention, as follows:

First, the strip metal plate 21 is subjected to a punching operation of the upper-side and lower-side molds 22 in order to prepare the primarily processed ladderlike strip metal plate 23 in which a group of needle fin units is formed. Then, the gear rolls 27 and the screw shafts 30 are rotated respectively, and the primarily processed strip metal plate 23 is fed to between the gear rolls 27 in order to obtain a secondarily processed strip metal

plate 25 which has been roughly formed into a wavy shape. Next, the secondarily processed strip metal plate 25 is fed to between the screw shafts 30 via the feeding guide 41, and then in this section, the tops of the blades 31 come in touch with the valleylike portions of the wavy metal plate 25 and cause the plate 25 to forward move with the aid of the rotation of the screw shafts 30. The wavy metal plate 25 is compressively formed by the blades having the gradually narrowed pitch so that the fin pitch of the plate 25 may become equal to a predetermined fin pitch P. The thus produced needle corrugated fin 23 is then disengaged from the blades and discharged through the discharge guide 42 as a product.

By operatively associating the gear rolls 27 with the screw shafts 30 at a constant rotational ratio, the needle corrugated fins 43 can be continuously formed. Further, it is possible by the use of the counter 44 to know the number of the corrugated fins 43 produced.

According to the apparatus of the present invention, the needle corrugated fins having the pitch of 0.8 to 1.0 mm can be obtained, though that of the conventional corrugated fins is 1.5 to 2.0 mm. Moreover, in the case of the present invention, it is unnecessary to apply a force to the tops of the fins at the time of the formation as in the conventional apparatus. Therefore, even if the

group of needle fin units has a small stiffness, the metal plate can be compressively formed into the predetermined fin pitch structure corresponding to the pitch of the blades with high accuracy, and the formation can be carried out easily and rapidly.

In the above given embodiment, reference has just been made to the formation of the strip metal plate having the group of ladderlike needle fin units, but the pattern of the fin is not limited to such a style. For example, the metal plate having a group of netlike needle fin units as shown in Figure 9 can also be compressively formed with ease by means of the apparatus of the present invention.

Now, a device for attaching reinforcing tapes to the aforesaid needle corrugated fin and a louver-having corrugated fin will be concretely described as follows:

Figures 10 and 11 are respectively a plan view and a cross-sectional view taken along line I - I therein, where means for maintaining the fin pitch of the corrugated fin according to the present invention are applied to the needle corrugated fin.

First, the wavy metal plate 50, which has been provided with a group of needle fin units and formed roughly into a wavy shape in the preceding process, is fed to between the screw shafts 52.

Each screw shaft 52 is provided with helical forming

blades 51 thereon so that intervals between the blades may become gradually narrow toward the front end of the screw shaft 52, and the respective screw shafts 52 are mutually arranged so that the blades 51 on one screw shaft may be placed at positions of 1/2 pitch of the blades on the other shaft.

By the rotation of both the screw shafts 52, the tops of the blades 51 are engaged with the valleylike portions of the wavy metal plate 50, and the wavy metal plate 50 is compressively formed into a closer wavy shape. Afterward, the wavy metal plate 50 is fed to between the pair of fin pitch-regulating screw shafts 53 disposed in an upper and lower relation in order to obtain a predetermined fin pitch.

The needle corrugated fin 6 will be joined to the heat transfer pipe 2, with opposite edges of the fin 6 in a width direction thereof directly connected to the pipe 2. Therefore, as seen best in Figure 12, tapes 54 are attached to the needle fin 9 adjacent to curved free areas 7, of the needle corrugated fin 6, in a plane crossing at right angle a plane including the edge portions which will be directly connected to the heat transfer pipe 2. For this purpose, tape-attaching mechanisms 55 are disposed in the vicinity of an outlet of the fin pitch-regulating screw shaft 53 and on right and left sides thereof when

viewed from plan.

In the tape-attaching mechanisms 55, the taps 54 which are wound on supporting shafts in a roll form are fed via tension rolls 56 and pressure rolls 57 for pressing the tapes against both the sides of the needle corrugated fin 6 to cause the former to adhere to the latter. During the feeding of the tapes, an adhesive is applied to an attaching surface of each tape 54 from adhesive-applying nozzle 58. The feeding speed of the tapes 54 and the speed of attaching them to the needle corrugated fin 6 are caused to coincide with the formation speed of the corrugated fin 6, so that the tapes 54 can smoothly be pressed against the curved portions 7 by the pressure rolls 57, thereby ensuring the adhesive attachment. As a result, the tapes 54 are adhesively and combinedly attached to the curved portions 7, which will not be directly connected to the heat transfer pipe 2, of the needle corrugated fin 6, as shown in Figure 12, whereby its desired fin pitch is maintained and its stiffness is heightened.

The needle corrugated fin 6 to which the tapes 54 has been thus caused to combinedly adhere is cut into a predetermined length each by means of a cutter not shown here, and the resultant products are afterward stocked. In this case, it is preferred that a high-energy non-contact cutting is carried out by using laser beam, light

beam or the like for the sake of innibiting a deformation of the fin by the cutting operation.

After the storage, the needle corrugated fin products 6 having the tapes 54 are inserted into between straight portions of the heat transfer pipe 2, and they are then dipped in a washing tank or the like containing a solution therein to dissolve the adhesive before securing, in order to remove the adhesive. Afterward, the needle corrugated fins 6 are secured to the heat transfer pipe 2 by brazing or another manner.

According to the present invention, it is assured that the adhesive attachment of the tapes 54 to the fin 6 can be accomplished while the former is pressed against the latter by the pressure roll 57 and while the fin 6 is carried by the fin pitch-regulating screw shafts 53, therefore the shafts 53 function as spacers in order to prevent the fin from being deformed by the applied force. Further, since the tapes are carried coinciding with the formation speed during the step of forming the corrugated fin, the combinative adhesion of the tapes can be accomplished at a high speed simultaneously with the formation of the fin.

In the louver-having corrugated fin 5 as shown in Figure 13, the tapes 54 are caused to combinedly adhere to the opposite edges in a width direction of the corrugated fin which are not directly connected to the heat

transfer pipe 2, because the portions which will be directly connected thereto are the curved portions 7 of the corrugated fin.

Incidentally, in the aforesaid embodiment, the tape-attaching mechanisms are disposed to the confronted screw shafts type corrugated fin-forming apparatus, but the forming apparatus to be used is not limited to the above type, and any apparatus can be employed. Further, the above tape can be made of an optional material such as paper, and an adhesive tape on which an adhesive has previously been applied can also be utilized, in this case the adhesive-applying nozzles can be omitted.

As understood from the foregoing, according to the present invention, the tapes are combinedly attached to the free areas, which are not directly connected to the heat transfer pipe, of the corrugated fin. Accordingly, the fin pitch of the formed fin can be uniformly maintained, and the stiffness of the corrugated fin can be enhanced. As a result, the produced fins are hard to be distorted or curved, and each of them can be handled as one block. Therefore, the insertion of the fins into between the straight portions of the heat transfer pipe can be mechanized and automated, which fact permits the manufacturing efficiency of the heat exchangers to be improved to a noticeable degree. Further, the tapes are combinedly

attached to the areas which are unconcerned with the connection to the heat transfer pipe. Therefore, after fins have been inserted between the straight portions of the heat transfer pipe, the adhesive can be removed by an easy operation such as a dip of them into the washing tank containing a solution to dissolve the adhesive, whereby a farther process of brazing can be carried out without any trouble. Furthermore, while stocked, the corrugated fins having the tapes are neither meddled in nor entangled by other adjacent fins, which fact can make their handling easy, for example, they can be carried smoothly to a farther step.

What is claimed is:

1. An apparatus for forming a corrugated fin for a heat exchanger, which comprises a pair of confronted gear rolls for roughly forming a strip metal plate into a wavy shape, and a pair of screw shafts rotatably disposed in parallel with a feeding passage of said roughly formed strip metal plate and on opposite sides of said feeding passage, said respective screw shafts being provided with helical blades on the outer peripheries thereof, said blades serving to compressively form said strip metal plate into a wavy shape having a predetermined fin pitch, by being brought into contact with valleylike portions of said strip metal plate.

2. An apparatus according to claim 1 wherein said strip metal plate is previously provided with a group of ladderlike or netlike needle fin units.

3. An apparatus for forming a corrugated fin for a heat exchanger, which comprises a device for forming a roughly wavy strip metal plate into said corrugated fin having a predetermined fin pitch, and tape-attaching mechanisms, disposed successively to said device, for attaching tapes to the opposite sides of said corrugated fin discharged from said device.

4. An apparatus according to claim 3 wherein said device for forming said strip metal plate into said corrugated

fin is a device comprising a pair of confronted gear rolls for roughly forming said strip metal plate into a wavy shape, and a pair of screw shafts rotatably disposed in parallel with a feeding passage of said roughly formed strip metal plate and on opposite sides of said feeding passage, said respective screw shafts being provided with helical blades on the outer peripheries thereof, said blades serving to compressively form said strip metal plate into a wavy shape having a predetermined fin pitch, by being brought into contact with valleylike portions of said strip metal plate.

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FIG. 1

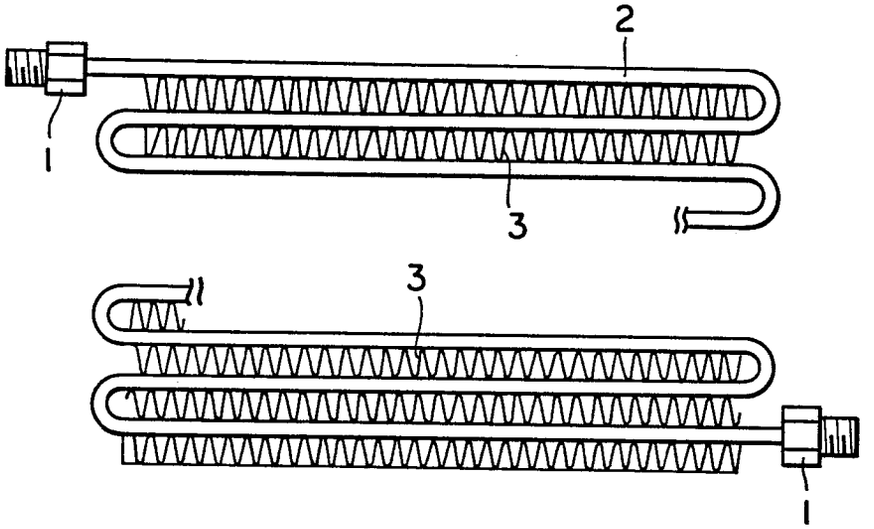

FIG. 2

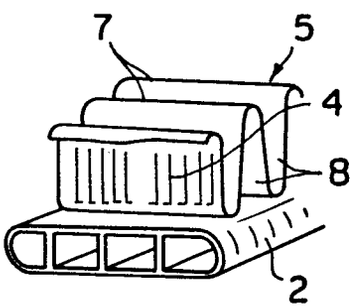

FIG. 3

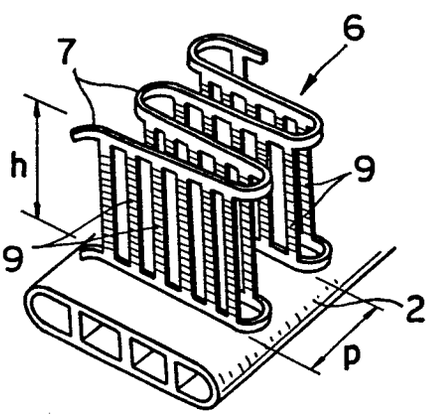

FIG. 4

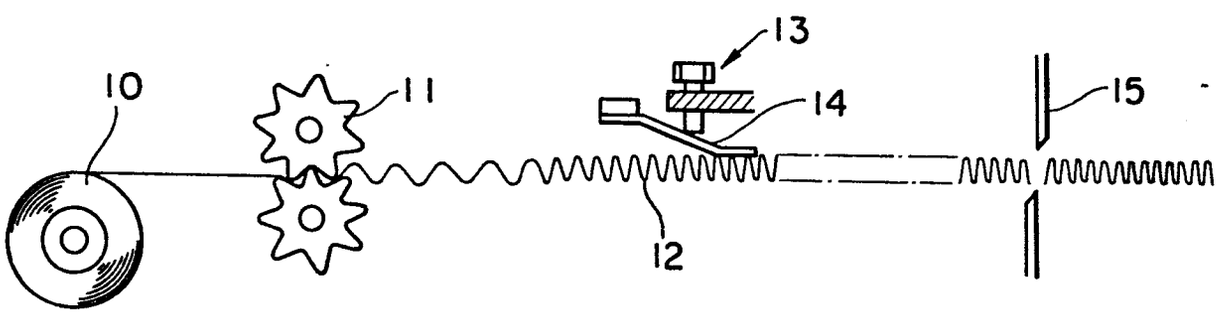

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FIG. 5

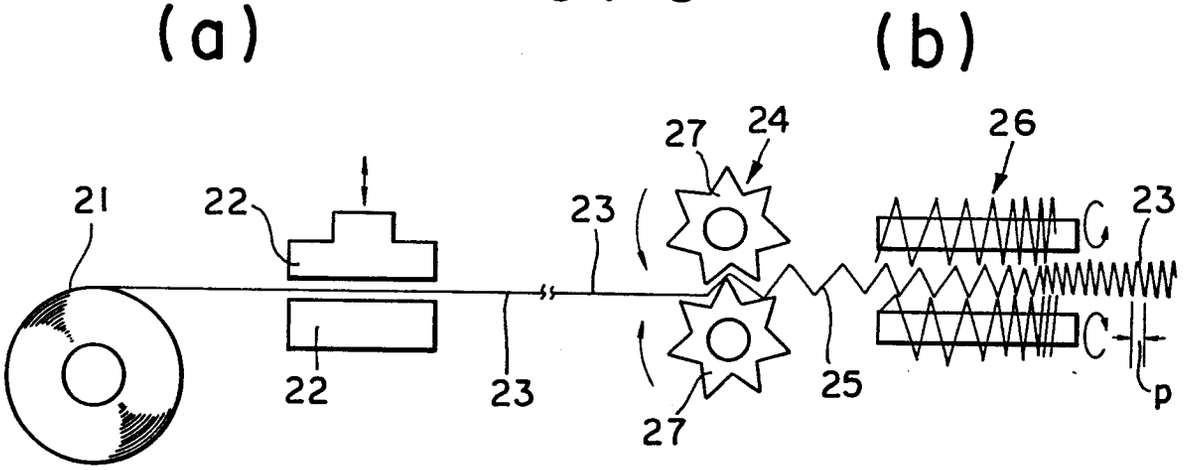

FIG. 6

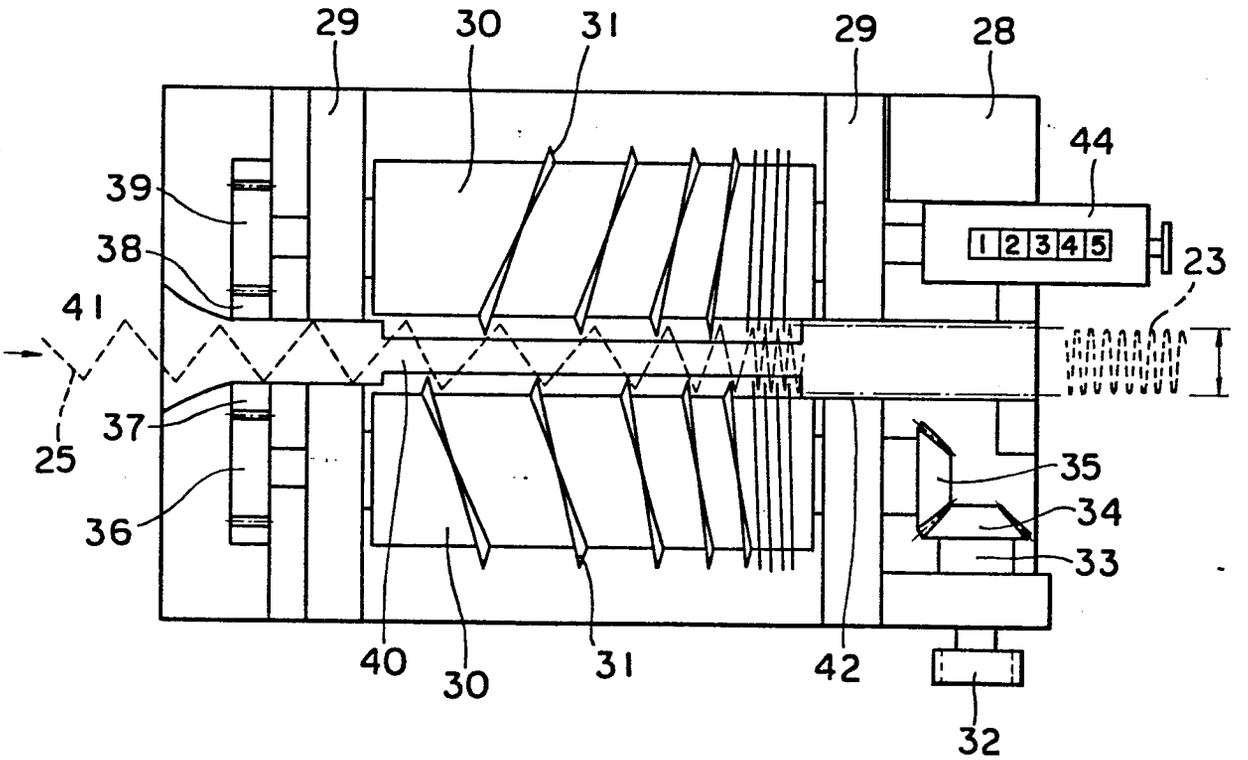

FIG. 7

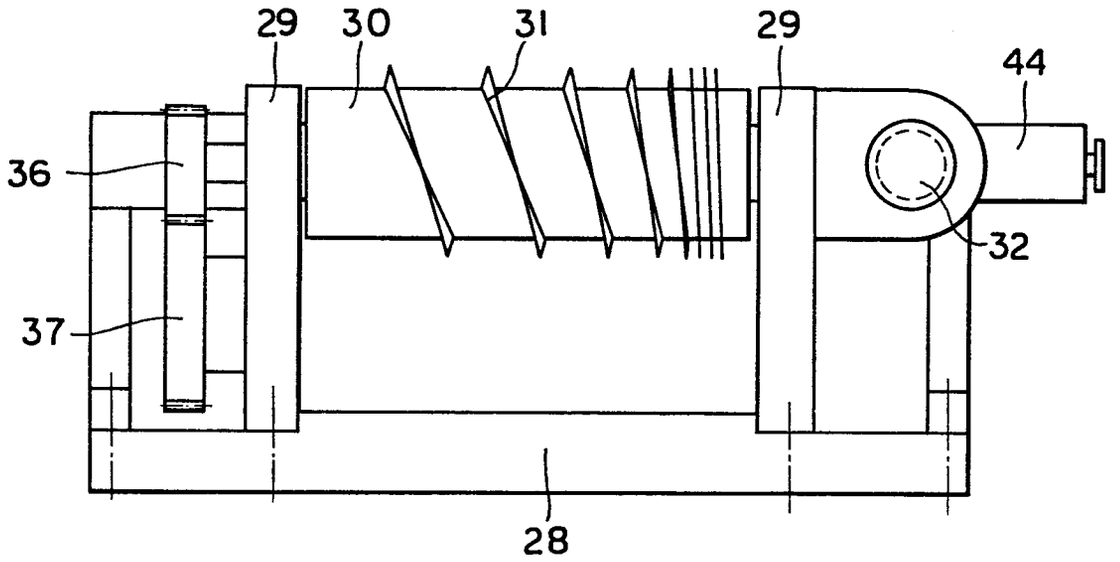

FIG. 8

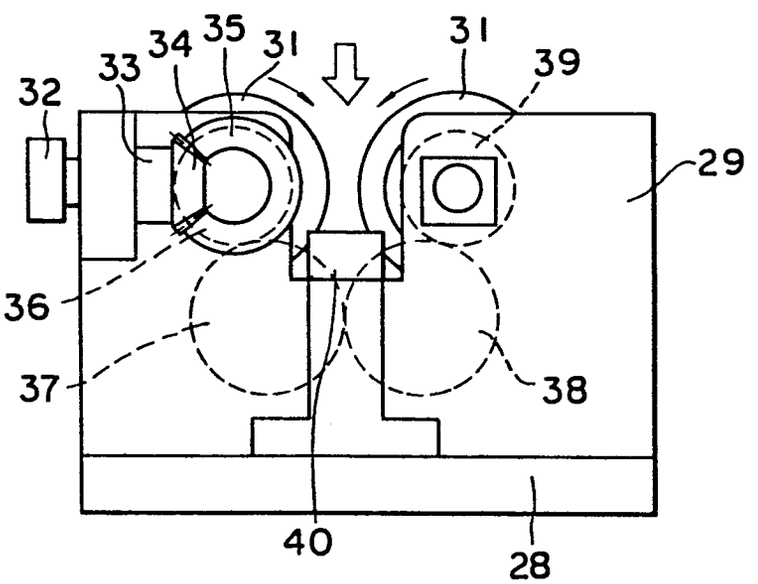

FIG. 9

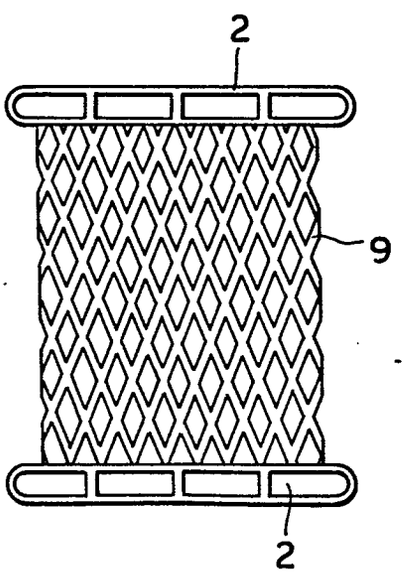

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FIG. 10

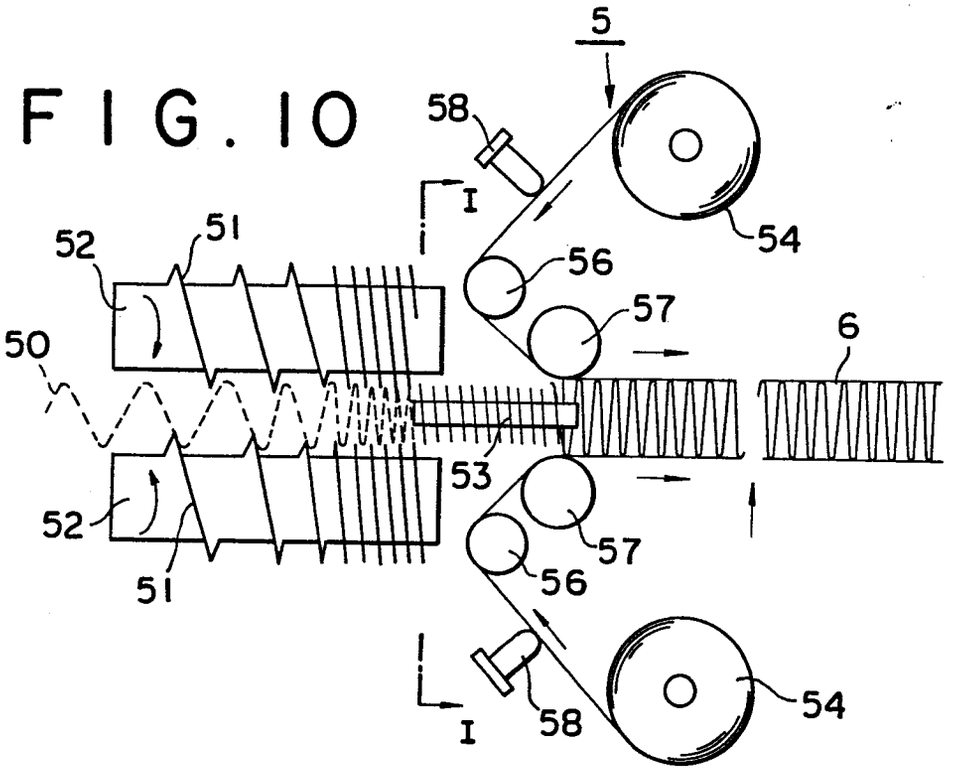


FIG. 11

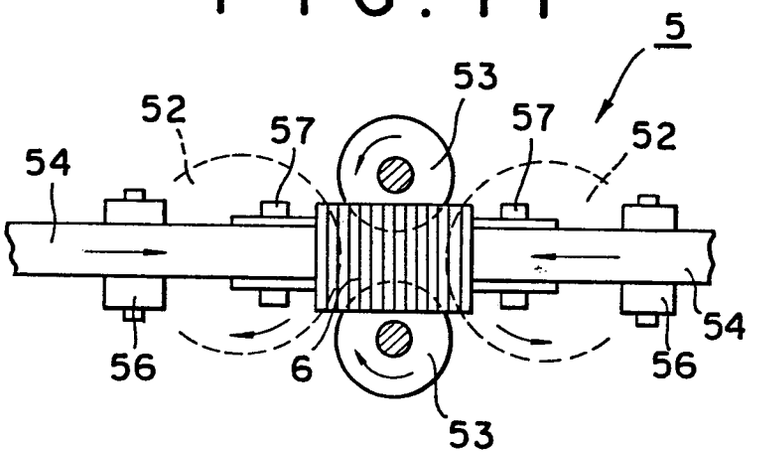


FIG. 12

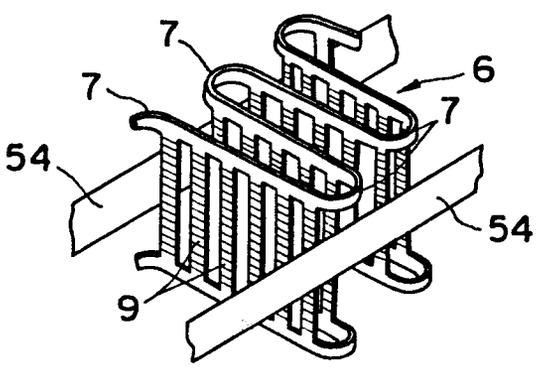
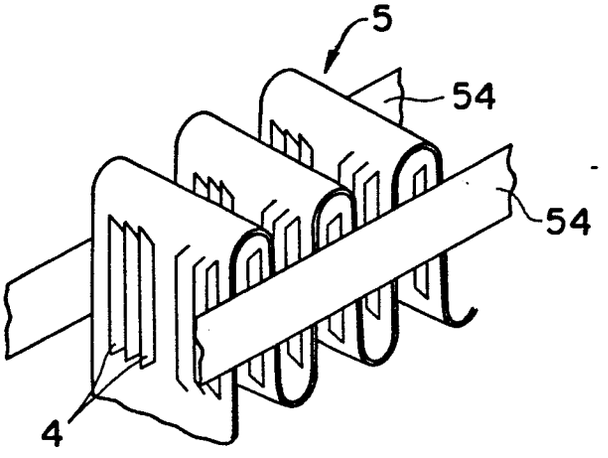


FIG. 13



European Patent Office

EUROPEAN SEARCH REPORT

0143136
Application number

EP 83 73 0084

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-3 137 337 (UNGERER) * column 3, lines 20-75; columns 4-7; column 8, lines 1-56; figures *	1	B 21 D 13/04
Y		3,4	

X	US-A-4 178 972 (PFAFFLE) * whole document *	1	
Y		3,4	

X	GB-A-1 282 199 (HERCKELBOUT) * page 3, lines 23-128; page 4; figures *	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30-11-1984	PEETERS L.

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0143136
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EP 83 73 0084

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
E	GB-A-2 118 881 (NIPPONDENSO CO.) * page 2, lines 100-125; page 3, lines 1-11; figures 1-4 *	1,2	
D,T	PATENTS ABSTRACTS OF JAPAN, vol. 7, no. 275 (M-261)(1420), 8th December 1983; & JP - A - 58 154 425 (MITSUBISHI JUKOGYO K.K.) 13-09-1983	1-4	
A	GB-A-1 042 237 (FORD MOTOR)		
A	DE-A-2 809 365 (SCHAEFER)		
A	PATENTS ABSTRACTS OF JAPAN, vol. 4, no. 96 (M-20)(578), 11th July 1980, page 44 M 20; & JP - A - 55 54 220 (MASAKI AKIBA) 21-04-1980	3	TECHNICAL FIELDS SEARCHED (Int. Cl.4)

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