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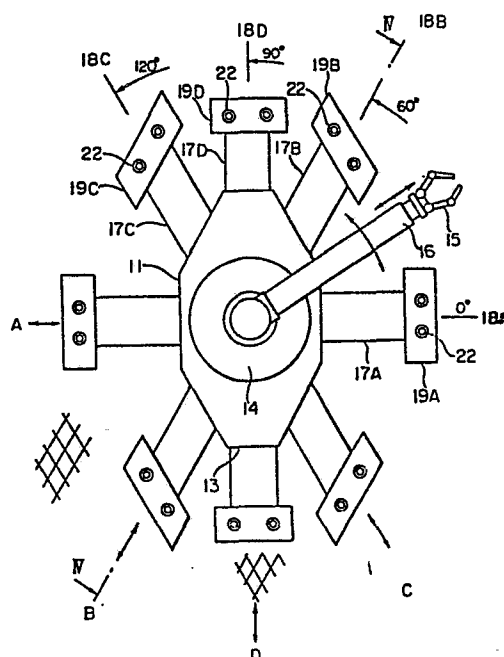
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(54) **Working robot used for the water chamber of the heat exchanger.**

(57) A working robot (1) positioned within a water chamber (3) of a heat exchanger comprises a body (11) of the working robot having an arm (16) rotatably mounted therein for supporting a working device (7), a unit (12) for supporting the body which is provided on the body, rails (17) for guiding the movement of the body and a unit (19) for supporting rails provided on both ends of the rails, the rails being composed of at least three sets of members (17A, 17B, 17C), a plurality of support shafts (21, 22) which are inserted into the interior of heat transfer tubes (25) of the heat exchanger such as to fixedly abut against the inner surface thereof being mounted on the body support unit and the rail support unit in the direction of the central axis of the heat transfer tubes.

FIG. 1



WORKING ROBOT USED FOR THE WATER CHAMBER
OF THE HEAT EXCHANGER

1 BACKGROUND OF THE INVENTION

The present invention relates to a device for transferring and holding a working robot which effects the inspection, maintenance or washing and the like,
5 of heat transfer tubes on the surface of a tube plate within the water chamber of the heat exchanger.

At present there are various manual tasks both dangerous and simple in nature which need to be carried out in the hostiled environment of thermal or atomic
10 power plants, calling strongly for the improvement thereof through automatization of the work.

As regards the heat exchanger, too, an eddy current test of the steam generator or the condenser needs to be carried out, both being dangerous and/or
15 difficult, and a variety of proposals have been made concerning methods of automatization of such tests.

As shown in Japanese Patent Laid-Open No. 10201/1976, for example, there is known an eddy current test automatization device intended for use with steam
20 generators, which can be shifted in the directions of X and Y by the use of a guiding shaft along with holding the device utilizing an expandable band at the end of a tap shaft fed into the heat transfer tube.

As well known, there are two sorts of arrays of
25 heat transfer tubes used in heat exchangers; in one type

1 the tubes are arranged in a checker-board fashion and
in the other the tubes are arrayed in a staggered fashion.
When travelling on the surface of a tube plate in an
array of the former type, the working efficiency of
5 transfer unit due to the freedom of movement in the
directions of the X and Y axes is very high.

In a great number of heat exchangers, however,
in order to improve the efficiency of heat transfer,
staggered tube arrays are used and flow-in lanes are
10 often partially provided in which no heat transfer tubes
are arrayed, to reduce the loss of pressure on the outer
side of the tubes. This flow-in lane is of such a con-
figuration that it will form a land portion which is
inclined by 60° or 120° relative to the horizontal or
15 vertical axis on the tube plate.

In the transfer device described above having
freedom of movement in the directions of the X and Y
axes, it is often difficult to readily jump this land
portion in dimensional terms, which calls for the develop-
20 ment of such a device as can be transferred readily and
efficiently on the surface of a tube plate of a heat
exchanger having the staggered-type tube array, since,
in such cases, the route of transfer and the construction
of the transfer device will be very complicated.

25 SUMMARY OF THE INVENTION

An object of the present invention is to provide
a working robot which can be transferred on the surface of
a tube plate in a case where the tubes are arrayed in a

1 staggered fashion so that the robot may effect a variety
of tasks.

The feature of the present invention, as shown
in Fig. 2, resides in the fact that, in the case of the
5 tubes being arranged in a staggered fashion, heat transfer
tubes are arrayed on the tube plate generally along the
inclined axis so that the transfer axis of a working
robot are set in at least three directions (horizontal
or vertical axis, and directions offset therefrom by 60
10 and 120°) to rationalize the manner of transfer of the
robot on the tube plate and simplify the transfer device.

When the surface of a tube plate is considered
separately in terms of (1) the sum of the holes in
which heat transfer tubes are inserted and fixed and
15 (2) the remaining area, the latter (2) is generally
smaller than the former (1). Thus the present invention
utilizes the holes for supporting the robot instead of
using the portion between the holes (2) aforementioned.

In order to achieve the above-mentioned object
20 in accordance with the above principle, the device for
transferring and holding a robot according to the
invention comprises a body of the working robot which
rotatably holds an arm for holding the working device,
a unit for supporting the body which is provided on
25 said body, a transfer rail for guiding the movement of
said body and a unit for supporting said rail, said rail
being composed of at least three sets of members and
a plurality of support shafts, which are inserted into
the inner surface of heat tubes such as to fixedly abut

1 against said inner surface, said plurality of support
shafts being mounted (in the direction of center of axis)
on said unit for supporting the body and the unit for
supporting the rail.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows an overall elevational view of an
embodiment according to the invention.

Fig. 2 shows an explanatory view illustrating
the array of heat transfer tubes of a heat exchanger.

10 Figs. 3 to 16 show embodiments of Fig. 2 and
in particular Fig. 3 shows a perspective view of a
working robot and a control apparatus.

Fig. 4 shows a cross sectional view taken along
the line IV-IV of Fig. 4.

15 Fig. 5 shows a cross sectional view taken along
the line V-V of Fig. 4.

Fig. 6 shows a rear view of a working robot.

Fig. 7 shows an explanatory view illustrating
an example of the array of support rods.

20 Figs. 8A to 10B show explanatory views of the
mechanism of a support unit.

Figs. 11 to 13 show explanatory views of a
transfer mechanism.

25 Fig. 14 shows an explanatory view of the
transfer route of the working robot.

Figs. 15 and 16 show working flow charts for
a robot.

1 Figs. 17A to 19 show explanatory views illustrating further embodiments of a transfer mechanism.

 Figs. 20 to 23 show explanatory views illustrating still further embodiments of a transfer mechanism.

5 Fig. 24 show a cross sectional view illustrating further embodiments of the telescopic mechanism of a working arm.

 Fig. 25 shows a cross sectional view illustrating further embodiments of the telescopic mechanism of a
10 working arm.

 Fig. 26 shows an overall elevational view illustrating a further embodiment of a working robot according to the invention.

 Fig. 27 shows a cross sectional view taken
15 along the line XXVII-XXVII of Fig. 26.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

 An embodiment according to the present invention will be hereinafter described referring to appended drawings.

20 Fig. 3 shows a construction of the subject device and peripheral units thereof working within the condenser of a power plant, the working robot being transferred along the surface of tube plate 4 positioned within the water chamber 3 of the condenser which is
25 connected to the condenser body 2 under the control of a control-operational unit 6 through the medium of a control cable. A working device 7 retained at the end of

1 the working arm is connected by the working cable 9 to
an operation control-recording unit 8 under the control
of which it effects the work while the robot is being
transferred and the results of operation are recorded on
5 the control-recording device 8. The robot 1 is carried
via a manhole in the side of the water chamber into the
interior thereof.

Figs. 1, 4 and 5 show overall constructions of
robot 1, Fig. 1 being an elevational view of robot 1 seen
10 from the side of the water chamber, Fig. 4 being a cross
sectional view taken along the line VI-VI of Fig. 1 and
Fig. 5 being a cross sectional view taken along the
line V-V of Fig. 4.

The body of robot 1 comprises a drive unit 12
15 for driving the body support unit 12, drive units 13A,
13B, 13C and 13D for driving rails 1, a drive unit 14 for
driving the working arm, a rotatable telescopic working
arm 16 having a handle 15 (Fig. 1) for holding the
working device at the end thereof, which is driven by
20 said drive unit 14.

The drive unit 13 for driving rails is intended
for driving rails 17A, 17B, 17C and 17D (Fig. 1). In
view of the fact that the tubes are arrayed in a check-
board and staggered fashion, each of the rails are
25 positioned on transfer axes A, 18A which coincide with
the horizontal axis of tube plate 14 as well as on
transfer axes B and 18B, C and 18C, and D and 18D inclined
by 60°, 120° and 90° relative to the shaft A.

1 Additionally, rails 17A, 17B, 17C and 17D are
mounted on each of the rail support units A, 19A, 19B,
C, 19C, D, 19D at both ends thereof.

 The positional relation between the body 11 and
5 each rail 17, as seen in Fig. 5 can be varied by actuating
an actuator 20 located within the interior of rail drive
unit 13B. Although not shown, the same can be said of
rail drive units 13A, 13C and 13D. Support rods 21 and
22 are each mounted parallel to the longitudinal axis
10 of heat transfer tube 25 located on the surface of tube
plate 4 within the interior of drive unit 12 (Fig. 4)
and drive unit 19 so that by the actuation of actuators
23 and 24 they can be freely fed into and drawn out and
from the interior of tube 25.

15 Fig. 6 shows a rear view of working robot 1 as
shown in Fig. 1, illustrating the location of working
rods 21 and 22.

 A plurality of supporting rods is disposed
such as to securely hold the body 11 of the working robot
20 and rail 17. The location of supporting rods 21, and
22 will depend upon the arrangement of tubes located on
the tube plate, Fig. 7 showing an example of the arrange-
ment thereof. Fig. 7 is an explanatory view of the
arrangement of supporting rods on the mesh 26 of a tube
25 plate in which tubes are arranged.

 Circles 21A and 22B marked on the mesh 26 each
denote the positions where supporting rods 21, and 22
are disposed. In view of the fact that the distance

1 between individual tubes within the heat exchanger
differs from one to the other, the drive unit 12 for
driving the body support device and the drive unit 19
for driving the rail support device may be provided
5 which coincide with each pitch of arrangement of tubes
to apply this robot 1 to a variety of heat exchangers.

Figs. 8 to 10 show enlarged views of a device
and mechanism for holding the working robot 1, especially
of the drive unit for driving the rail support device.

10 Figs. 8A, 9B and 10B represent side elevational views
respectively of Fig. 8A, 9A and 10A.

The holding device comprises the drive unit for
driving the rail support device, the support rod 22, an
air bag pad 31, an air pipe 32, and a flange as a stopper,
15 the holding action being effected in accordance with
the following steps.

Step 1 (see Fig. 8A and 8B); make the central
axes of support rod 22 and the heat transfer tubes 25 on
the tube plate coincide with each other.

20 Step 2 (Figs. 10A and 10B); the air is fed via
the air pipe 32 into the air bag pad to expand the pad
until it contacts the inner surface of heat transfer tube
25, thus generating holding force.

To release the holding action, the above-
25 mentioned steps may be reversed. The present holding
mechanism is completely identical to that of the drive
unit for driving the body support device.

Next, Figs. 11 to 13 show the mechanism for

1 moving a working robot. In this case, take as an example
a case in which the robot is held by the rail holding
mechanism and the body of robot 11 is positioned at the
lower end of rail 17.

5 Step 1 (see Fig. 11); the body 11 of the robot
is moved to the upper end of rail 17 by actuating the
actuator of the rail drive unit 13.

Step 2 (see Fig. 12); after aligning the
support rod 21 with the central axis of the heat tube,
10 the rod 21 is fed into the interior of heat transfer tubes
so that the body 11 of the robot may be supported by said
body holding mechanism. Thereafter, the rail support
mechanism is released to draw out the support rod 22
from the interior of heat transfer tubes and, by actuating
15 the actuator of the rail drive unit, to move the rail 17
upwardly.

Step 3 (see Fig. 13); after aligning the support
rod 22 with the central axis of the heat transfer tube,
the rod 22 is fed into the interior of the heat transfer
20 tube to allow the rail 17 to be held by the rail holding
mechanism. Thereafter the robot body holding mechanism
is released to draw out the support rod 21 from the
interior of the heat tube.

At the end of step 3 the condition in which the
25 working robot 1 is held is restored to the one mentioned
in step 1, the working robot 1 being moved upwardly by
the repetition of similar actions.

Further, the principles of movement of the

1 robot along other axes are completely the same as this
basic one.

Fig. 14 shows the method of producing a part
of transfer route 41 on the surface of tube plate 4 of
5 robot 1, taking the condenser used for the power plant by
way of example.

A hand for holding the working device of robot
1 according to the present embodiment has degrees of
freedom 3 and 1 respectively in the rectilinear direction
10 of travel of three rails 17 and in the direction in
which working arm 16 is extended. Consequently, it is
clear that the holding hand 16 can reach every coordinate
2 (r, θ) positioned on the surface of the tube plate.
Furthermore, the holding handle 16, in addition to
15 travelling along axes X and Y, can implement the work on
the tube plate along the extremely simple and efficient
transfer route 41 shown in this Figure since a transfer
axis is used which especially suits the tube arrangement.
This transfer route may be decided such that, by drawing
20 a circle 42 which corresponds to the central radius of
the hand, a terminal end of each travel path constituting
the travel route being taken as a center, graphics
obtained by enveloping these circles may envelope all
heat transfer tubes.

25 Figs. 15 and 16 show flow charts for the
travelling and operation of a working robot according to
the present embodiment, each block being described in
greater detail as follows:

1 Start: Input into a control unit of a matrix
of heat transfer tubes located on the tube plate;

Coordinates on which heat transfer tubes are
located are constructed into a matrix and are input to
5 the control and operational unit so as to be used as the
basic control data.

Mounting of the working robot; the working
robot 1 is mounted on the surface of tube plate 4 as well
as mounting position being inputted as the initial value
10 in the control and operational unit.

Formation of the optimum transfer route by the
control unit; the transfer route as shown in Fig. 14 is
calculated by the control unit. At the same time data
is prepared as to the travel path (minor transfer route
15 of the same transfer axis) constituting the transfer
route and the travel step forming the travel path (travel
action for moving the rail) for the purpose of enabling
the subsequent control of the robot.

The transfer of the robot along the rail; the
20 robot transfer action is implemented for moving the
rail.

Decision as to range of heat transfer tubes;
the rail is fixed from this stage on.

Heat transfer tubes are picked up which can be
25 covered by the robot body being moved on the rail.

Setting of operation sequence of heat transfer
tubes; the operation sequence for the heat transfer tubes
is set in accordance with what has been previously

1 determined.

Hereinafter values r , and θ are calculated as to each heat transfer tube;

Travelling of robot body and rotation of working
5 arm; the appropriate action capable of minimizing the travel of robot body is selected so that power consumption may be minimized, the center of the working hand being aligned with said coordinates r , and θ by moving the robot body and rotating the working arm.

10 Implementation of robot operation;

Recording of operation results; results of operation are recorded in the operation control and recording unit.

Termination; the afore-mentioned flow has
15 three kinds of repetitive loops, which are illustrated by loops A, B and C as in Figs. 15 and 16.

According to the present embodiment as described herein, the working robot used within the water chamber of a heat exchanger can be constructed with an extremely
20 simple mechanism which needs a reduced degree of freedom of movement and which is economical as well.

Figs. 17A to 19 show further embodiments according to the present invention which, as compared with the ones shown in Figs. 8A to 10B, differ in the
25 holding mechanisms used for holding the robot body and rail.

Fig. 17A shows an enlarged view of the drive unit 19 for driving the rail holding unit and Fig. 17B

1 shows a side profile thereof. Fig. 17 differs from the
embodiment shown in Fig. 8 in that a pad 51 is provided
at the end of the rod comprising hard rubber, or the like
whose outer diameter is smaller than the inner diameter
5 of heat transfer tube 25.

Fig. 18 is an explanatory view illustrating
schematically the front view of the drive unit for driving
the rail support unit wherein the support rod 22 can be
moved not only in the perpendicular direction (in the
10 longitudinal direction of the axis of the heat transfer
tube) relative to the surface of a tube plate, but also
parallel to the tube plate, i.e., in the direction in
which the distance between support rods 22 and 22 can be
increased or decreased. The holding mechanism according
15 to the present embodiment differs in the aforementioned
step 3 from the embodiment shown previously. In step 3
the support rod 22, as shown in Fig. 19, is moved hori-
zontally, as shown by a pair of arrows in Fig. 18, by
the actuator positioned within the drive unit such as
20 to press the outer surface of pad 51 against the inner
surface of heat transfer tubes 25 so that the heat
transfer tube 25 can be clamped, as shown in Fig. 19.
This holding mechanism is also the same as the one for
the drive unit 12 for driving the body support unit.

25 According to the present embodiment, since the
support rod 12 can be moved at a right angle relative to
the central axis of a heat transfer tube, the working
robot 1 can be used on a variety of surfaces of tube

1 plates having different pitch arrangements without
replacing the drive unit 19 for driving the rail support
unit 1 and the drive unit 12 for driving the body support
unit.

5 Figs. 20 to 23 show further embodiments
according to the present invention, which differ from
those described previously in the holding mechanisms for
holding the robot body and the rail.

Fig. 20 is an enlarged view of the drive unit
10 19 for driving the rail support unit, which differs from
Figs. 8 and 17 in that a pad comprising a holding band
61 and a band stiffener 62 is provided at the end of a
rod. Moreover, an air pipe 63 and the electric cable 64
are connected to said pad. The holding band is made of
15 a plurality of configuration memorizing alloys which are
formed at a high temperature in such a form as that
shown in Fig. 21, the surface S being constructed in a
columnar form.

Fig. 22 shows a cross sectional view of a pad
20 under ordinary temperature conditions within which is
provided a coiled spring 65, the band stiffener 62A
being slidable relative to the support rod 22 and the
stiffener 62B being fixed.

As shown in this Fig. 22, at a cold temperature
25 the holding band extends under the action of coiled
spring 65 in the axial direction of support rod 22 so
that the outer diameter thereof becomes smaller than the
inner diameter of heat transfer tube 25.

1 Fig. 23 shows such a condition in which the
holding pad 61 is supplied with current and heated by the
electric cable 64. The holding band 61 heated to a high
temperature by current heating compresses the coiled
5 spring 65 by the action of the configuration memorizing
alloy so that it may assume a form as shown in Fig. 21,
the outer diameter thereof being increased as shown in
Fig. 23. The air pipe 63 connected to the pad is intended
for cooling the holding band and, after the supply of
10 current has been stopped, feeds the cooling air and the
band is restored in a short time to the condition shown
in Fig. 22.

The holding mechanism according to the present
embodiment differs from the aforementioned example in
15 Step 3. (In Steps 1 and 2 the pad assumes the condition
shown in Fig. 22 so that it can be fed into the interior
of a heat tube); in Step 3 by feeding the current via
the electric cable 64 to heat the pad, the latter is
expanded as shown in Fig. 23 such as to be pressed
20 forcibly against the interior of heat transfer tube 25.
The air flows out via the air pipe 63 after the current
is stopped such as to release the holding action and
after the pad has been restored to the situation shown in
Fig. 22, the support rod 22 is drawn out from the inner
25 surface of heat conduction tube 25. The holding mechanism
according to the present embodiment is identical with
that of the drive unit 12 for driving the body support
device.

1 According to the present embodiment, thanks to
the use of configuration memorizing alloy, the pad
expanding mechanism can be simplified, to thereby simplify
the structure of the robot and reduce the weight thereof.

5 Fig. 24 shows an embodiment of the telescopic mechanism
of the working arm 16, the shaft of arm 66 being slidably
inserted into the tubular body 67 and threadably connected
with the drive shaft 68.

 The cross sectional configurations of the arm
10 shaft 66 and the tubular body 67 are, for example,
equilateral polygons which can not be rotated relative
each other. The drive shaft 68 is rotated by the drive
motor 69 so that the working arm 16 will be telescoped
due to the threadable connection with the arm shaft 66.

15 Fig. 25 shows a further embodiment of a
telescopic mechanism of the working arm 16 wherein the
arm shaft 66 positioned within the air cylinder 70 is
driven pneumatically so that it is easily telescoped.
Arrows show the direction in which the air flows in and
20 is discharged. Figs. 26 and 27 show further embodiments
of a working robot, which differ from the one shown in
Fig. 1 in that they comprise three sets of rail drive
units 13A, 13B and 13C and rails 17A, 17B and 17C and
rail support units 19A, 19B and 19C, respectively.

25 Taking into consideration the staggered array
of tubes, each rail is disposed on the axis A, 18A which
coincides with the horizontal axis (the vertical axis
depending on the tube array) and on the axis B, and

1 18B and C and 18C which are inclined 60° and 120° relative
to said axis A. Additionally, the working arm 16 provided
with the hand 15 for holding the working unit may be
non-telescopic. The holding mechanism according to
5 the present embodiment may be chosen from a variety of
holding mechanisms as preciously described referring to
Figs. 8A to 10B, 17A to 19 and 20 to 23. The travelling
mechanism of the working robot according to the present
embodiment is identical with those described referring
10 to Figs. 11 to 13.

The present invention makes it possible to
provide a travelling and holding unit suitable for use in
a working robot, which travels on the surface of a tube
plate wherein tubes are arrayed in a staggered fashion
15 within the water chamber of a heat exchanger, and provides
the following advantages;

(a) As a result of the shift axis being provided
to the moving unit in consideration of the arrangement
of the heat transfer tubes, the mechanism for changing
20 the route of the working robot can be extremely simplified,
thus making it possible to drastically simplify the robot
control logic.

(b) Due to the matters defined in (a), the dangerous
and difficult work which needs to be effected within
25 water chambers such as those of steam generators and
condensors can be completely automatized, lending itself
to the elimination of the need for human labor in the
dangerous work of maintaining power plants and increasing
the safety of inspection work.

CLAIMS

1. A working robot (1) positioned within a water chamber (3) of a heat exchanger comprising:

a body (11) of the working robot having an arm (16) rotatably mounted therein for supporting a working device (7), a unit (12) for supporting the body which is provided on said body, rails (17) for guiding the movement of said body and a unit (19) for supporting rails provided on both ends of said rails, said rails being composed of at least three sets of members (17A, 17B, 17C), a plurality of support shafts (21, 22) which are inserted into the interior of heat transfer tube (25) of said heat exchanger such as to fixedly abut against the inner surface thereof being mounted on said body support unit and said rail support unit in the direction of the central axis of said heat transfer tubes.

2. A working robot (1) positioned within a water chamber (3) of a heat exchanger comprising:

a body (11) of the working robot holding telescopically and rotatably an arm (16) for supporting a working device (7), a unit (12) for supporting the body which is provided on said body, rails (17) for guiding the movement of said body and a unit (19) for supporting rails provided on both ends of said rails, said rails being 4 sets of members (17A, 17B, 17C, 17D) and a plurality of support shafts (21, 22) which are inserted into the interior of heat transfer tubes (25)

of said heat exchanger to fixedly abut against the inner surface thereof being mounted on said body support unit, said rail support unit in the direction of the central axis of said heat transfer tubes.

3. A working robot (1) positioned within a water chamber (3) of heat exchanger as defined in Claim 2 wherein each of said plurality of support shafts (21, 22) is provided with a means for driving said support shaft in the direction of center of axis of heat transfer tube (25) as well as for holding said shaft slidably in said direction and at the end thereof a container (31) is mounted which expands and contracts due to the injection and discharge of compressed air so that when said container contracted said shaft can be slidable within the heat transfer tube and when it expanded it can be held in an intensive abutment with the inner wall.

4. A working robot (1) positioned within a water chamber (3) of heat exchanger as defined in Claim 2 wherein said support shaft (21) provided to the body support unit (12) and support shaft (22) provided to the rail support unit (19) are constructed respectively in a plural number such that the distance between one another can be varied and the heat transfer tube (25) is clamped by support shafts inserted therein to in abutment with the surface of inner wall thereof to allow said support shafts to be fixed.

5. A working robot (1) positioned within a water chamber (3) of heat exchanger as defined in Claim 2

wherein each of said plurality of support shafts (21, 22) is provided with a means for driving said support shaft in the direction of center of axis of heat transfer tube as well as for holding said shaft slidably and a pad (61) made of configuration memorizing alloy which is deformed by the heating to increase a diameter thereof.

6. A working robot (1) positioned within a water chamber (3) of a heat exchanger comprising:

a body (11) of the working robot holding rotatably an arm (16) for supporting a working device (7), a unit (12) for supporting the body which is provided on said body, transfer rail (17) for guiding the movement of said body and a unit (19) for supporting rails which is provided on both ends of said rails, said rails being constructed of three sets of members (17A, 17B, 17C, 17D) intersecting at an angle of 60 with each other and a plurality of support shafts (21, 22) which are inserted into the interior of heat transfer tube (25) of said heat exchanger to fixedly abut against the inner surface thereof, being mounted to said body support unit and both ends of rail in the direction of center of axis of heat transfer tube.

7. A working robot (1) positioned within a water chamber (3) of heat exchanger as defined in Claim 6 wherein each of said plurality of support shafts (21, 22) is provided with a means for driving said support shaft in the direction of center of axis of heat transfer tube (25) as well as for holding slidably said shaft in

said direction and a container (31) at the end thereof which expands and contracts due to the injection and discharge of compressed air, said support shaft being slidable within the heat transfer tube when said container contracted and said support shaft being held in strong abutment with the inner wall of heat conduction tube when said container expanded.

8. A working robot (1) positioned within a water chamber (3) of heat exchanger as defined in Claim 6 wherein said support shaft (21) provided to the body support unit (12) and the support shaft (22) provided to the rail support unit (19) are constructed respectively in a plural number such that the distance between one another and the heat transfer tubes (25) are clamped by support shafts inserted therein in abutment with surface thereof to allow support shafts to be fixed.

9. A working robot (1) positioned within a water chamber (3) of heat exchanger as defined in Claim 6 wherein each of said plurality of support shafts (21, 22) is provided with a means for driving said support shaft in the direction of center of axis of heat transfer tube as well as for holding said shaft slidably and a pad (16) made of configuration memorizing alloy which is deformed by heating to increase a diameter thereof.

10. A working robot (1) positioned within a water chamber (3) of heat exchanger as defined in Claim 6 wherein said body (11) of working robot holds the arm (16) for supporting said working device (17) rotatably

by 360°.

11. A working robot (1) positioned with a water chamber (3) of heat exchanger as defined in Claim 6 wherein said body (11) of working robot holds telescopically the arm (16) for supporting said working device (7).

FIG. 1

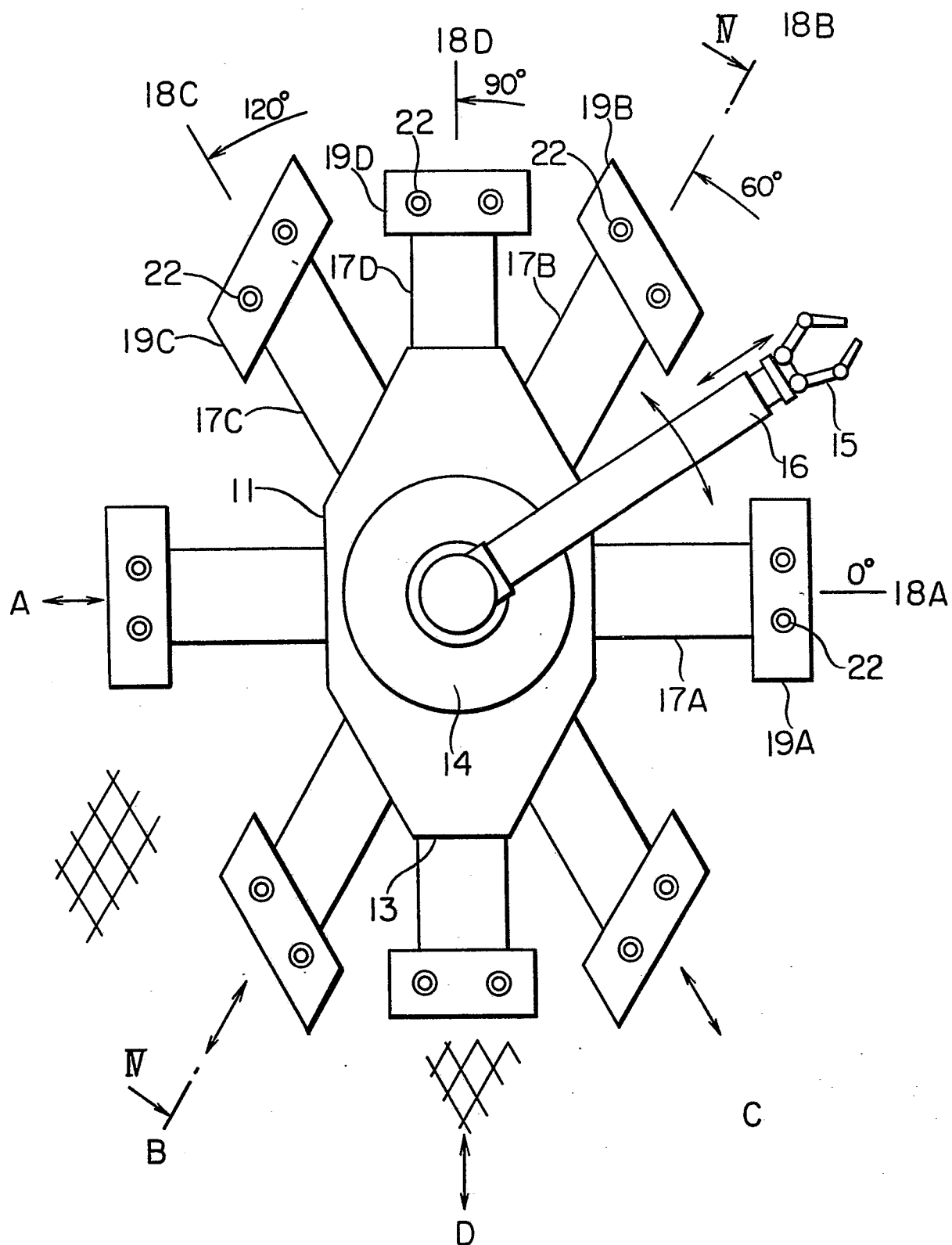


FIG. 3

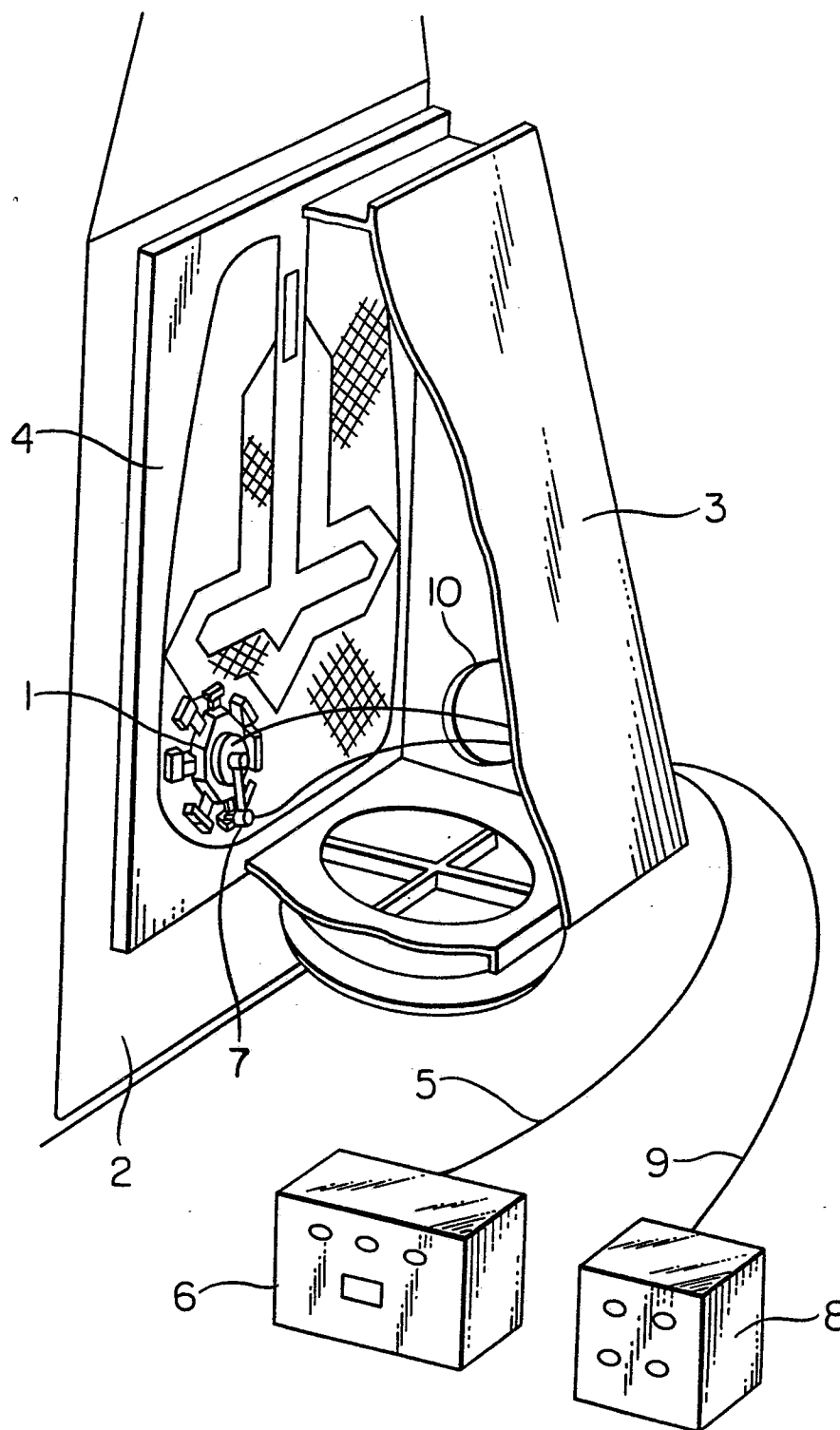


FIG. 4

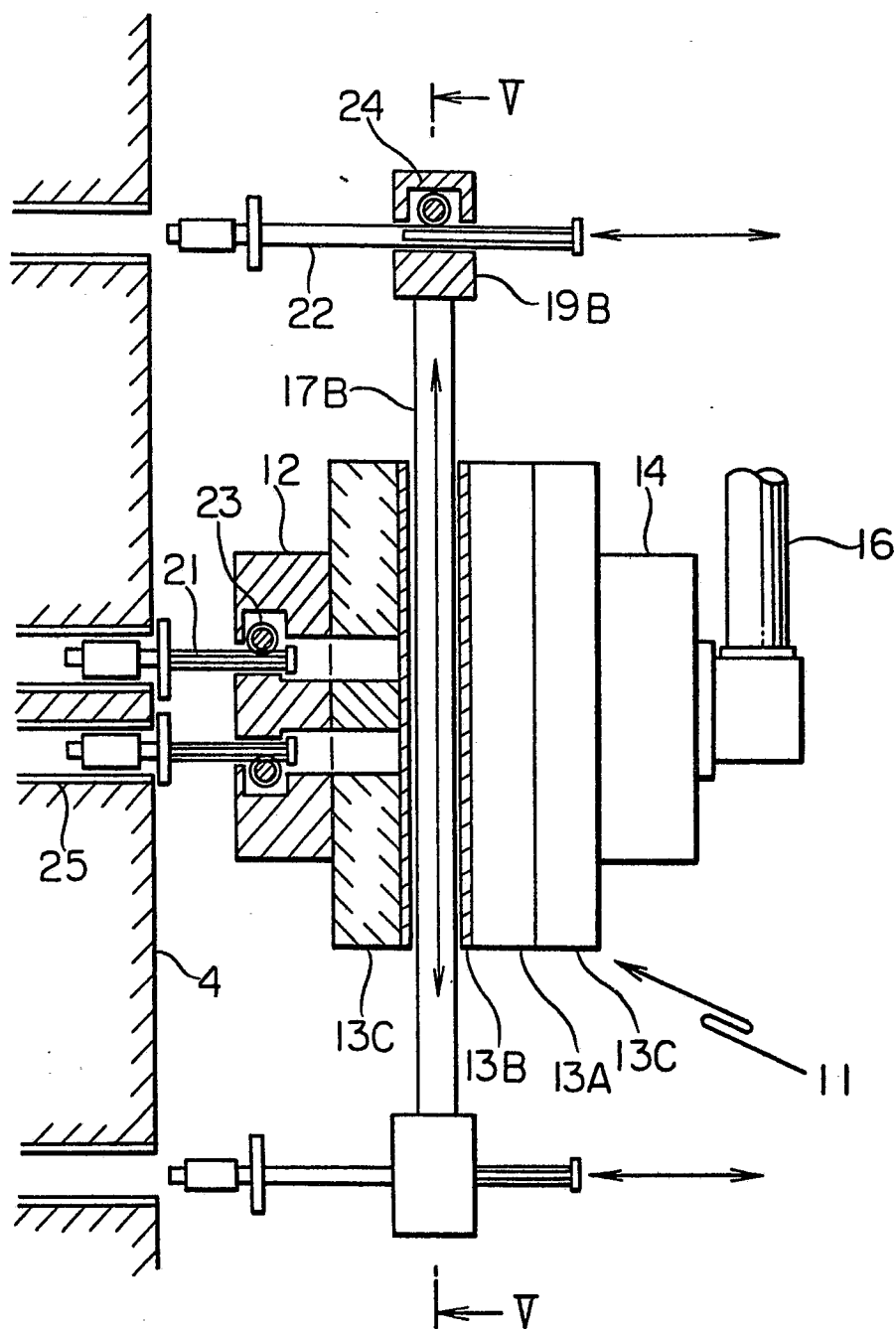


FIG. 5

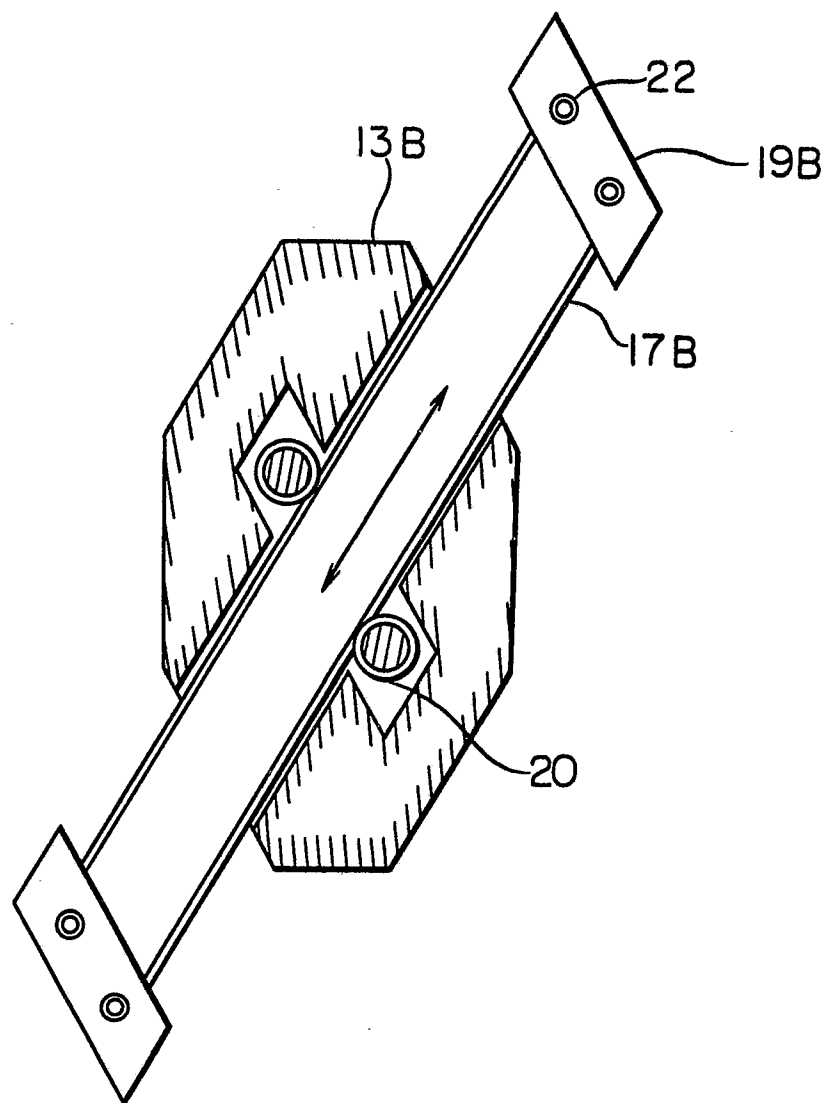


FIG. 6

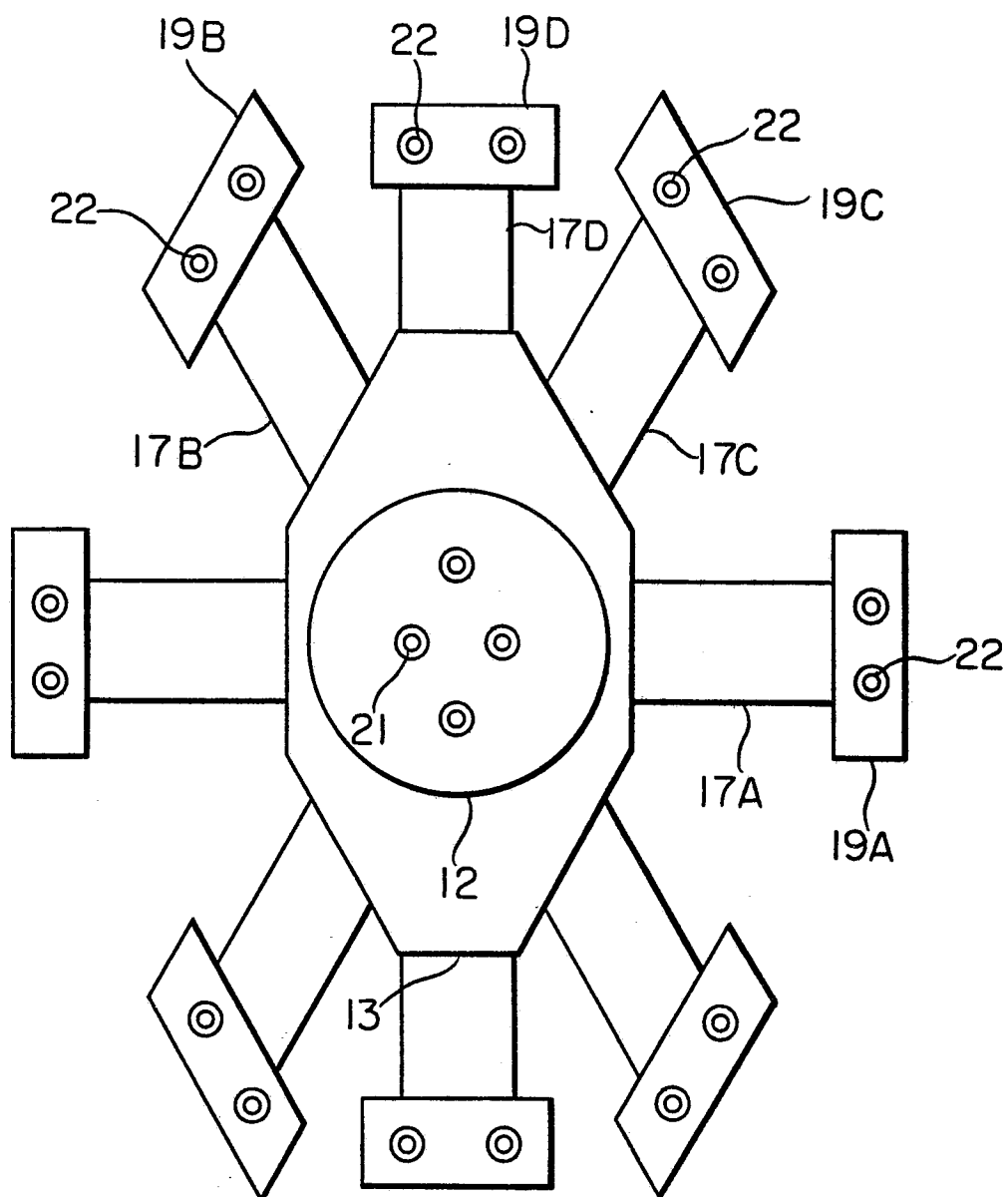


FIG. 7

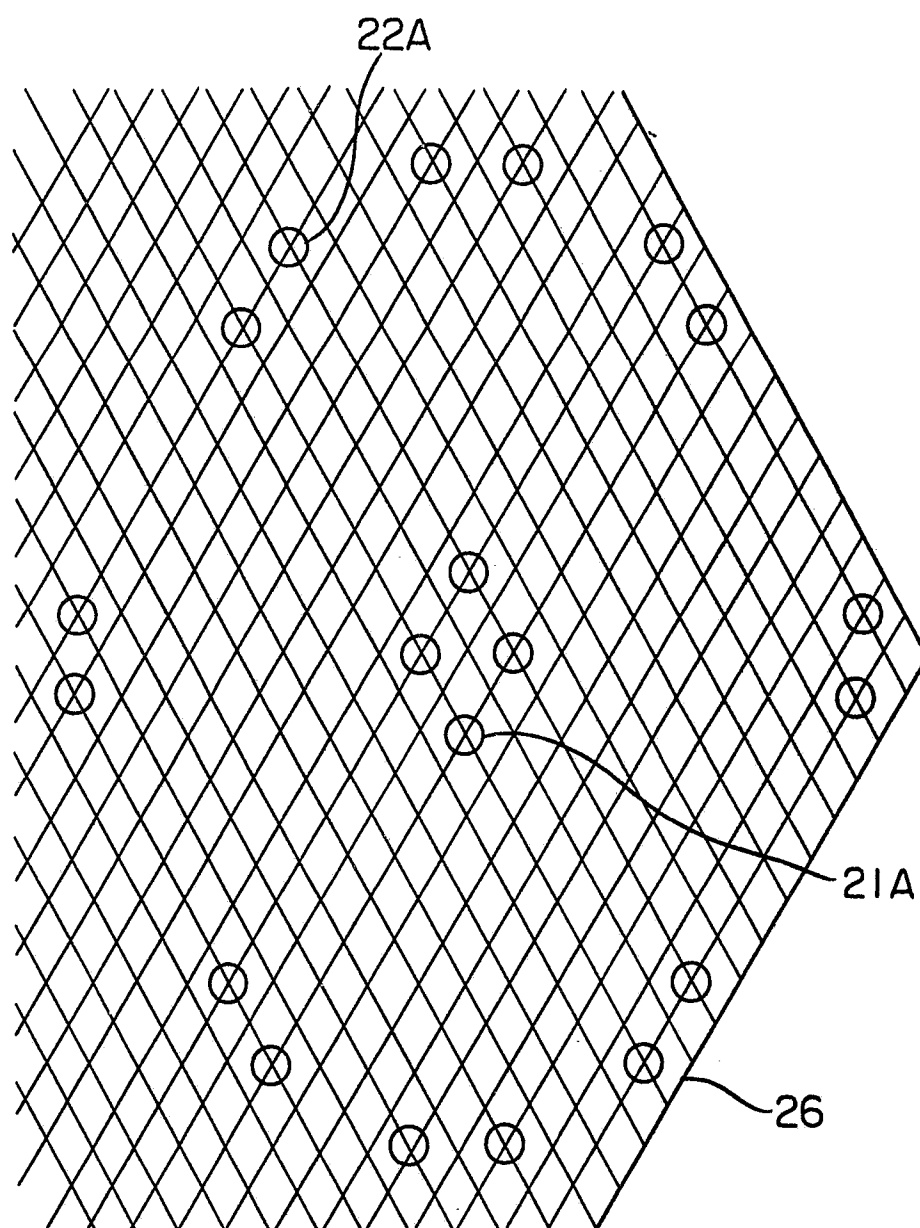


FIG. 8A

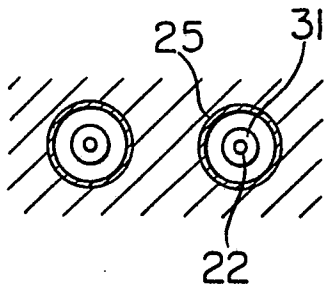


FIG. 8B

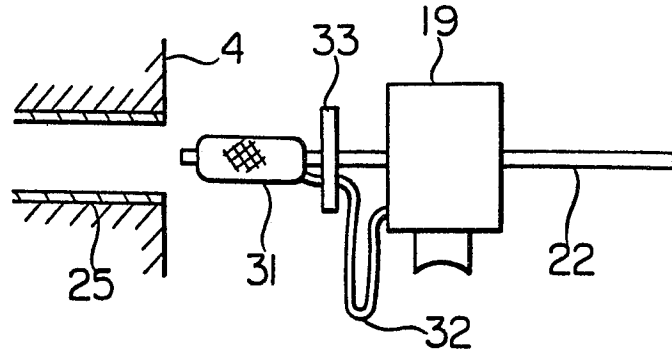


FIG. 9A

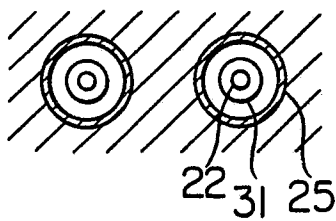


FIG. 9B

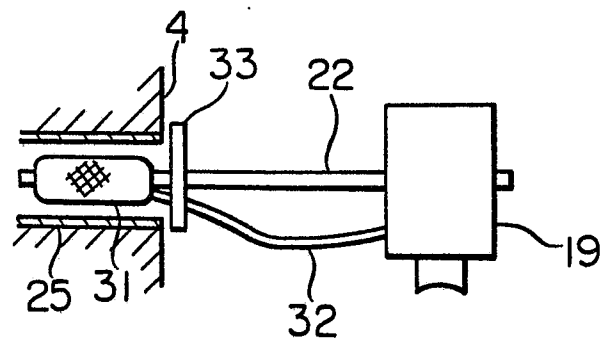


FIG. 10A

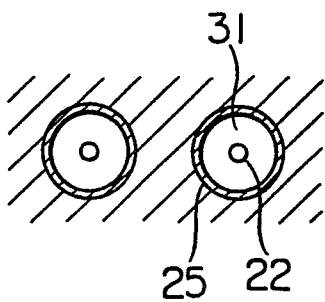


FIG. 10B

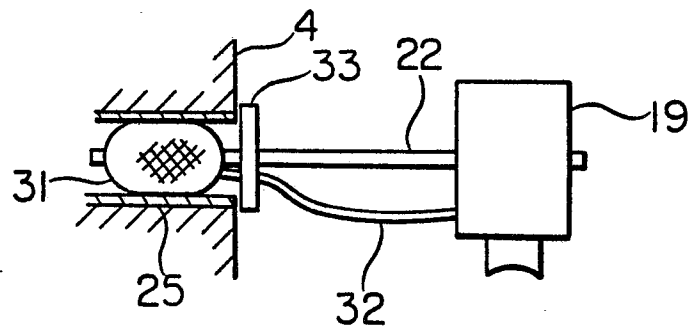


FIG. 11

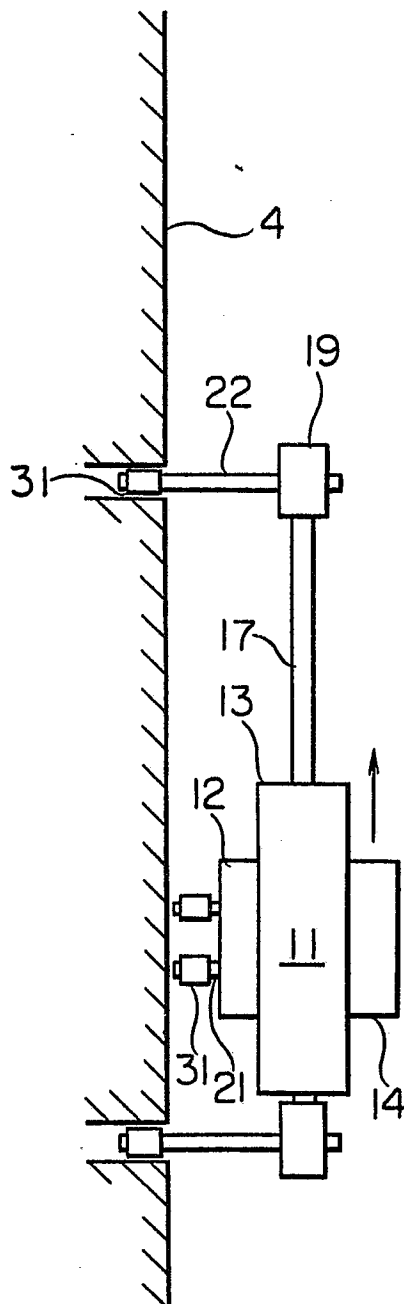


FIG. 12

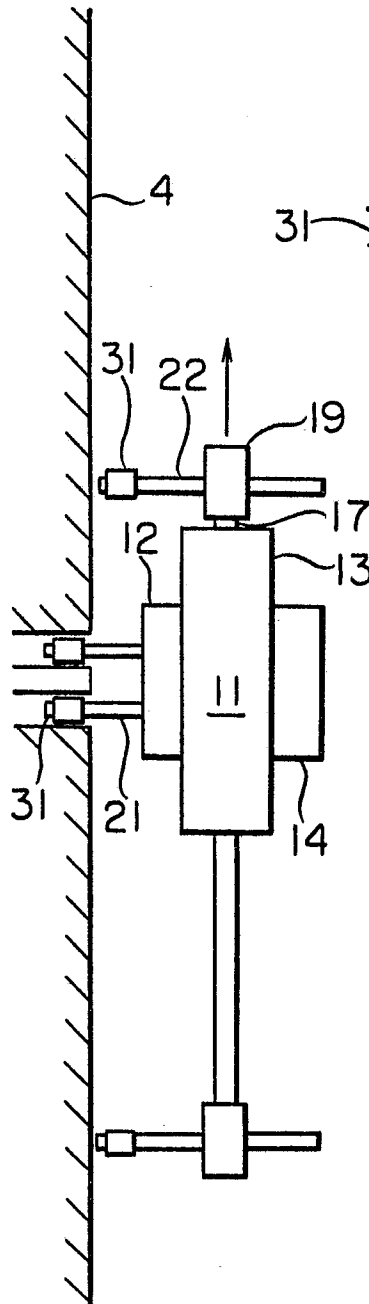


FIG. 13

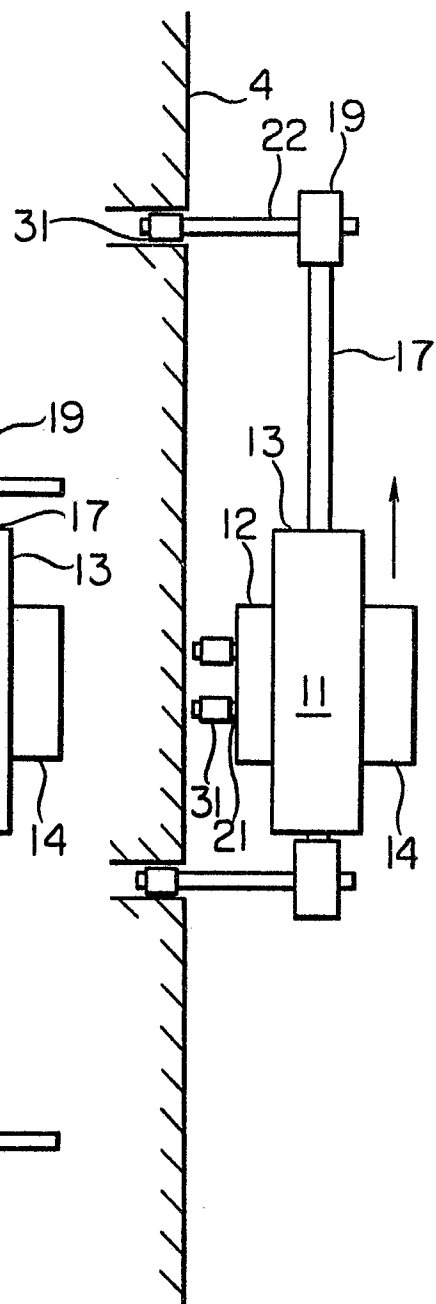


FIG. 14

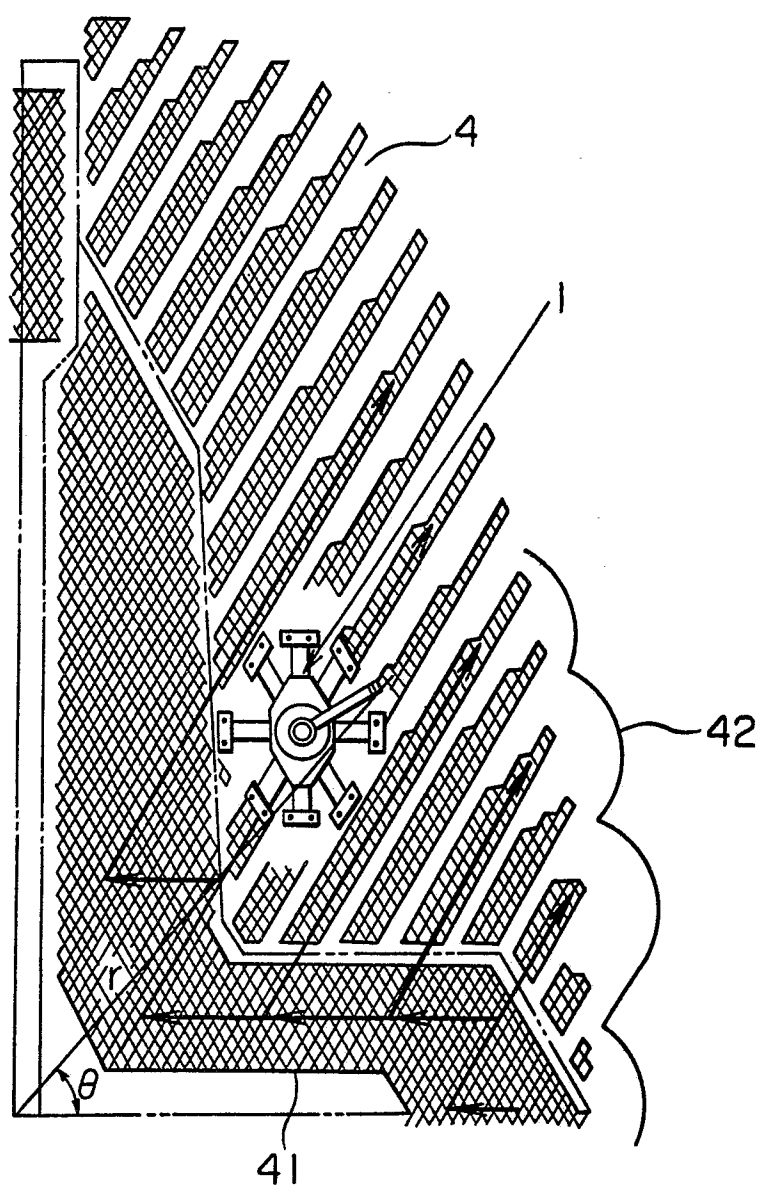


FIG. 15

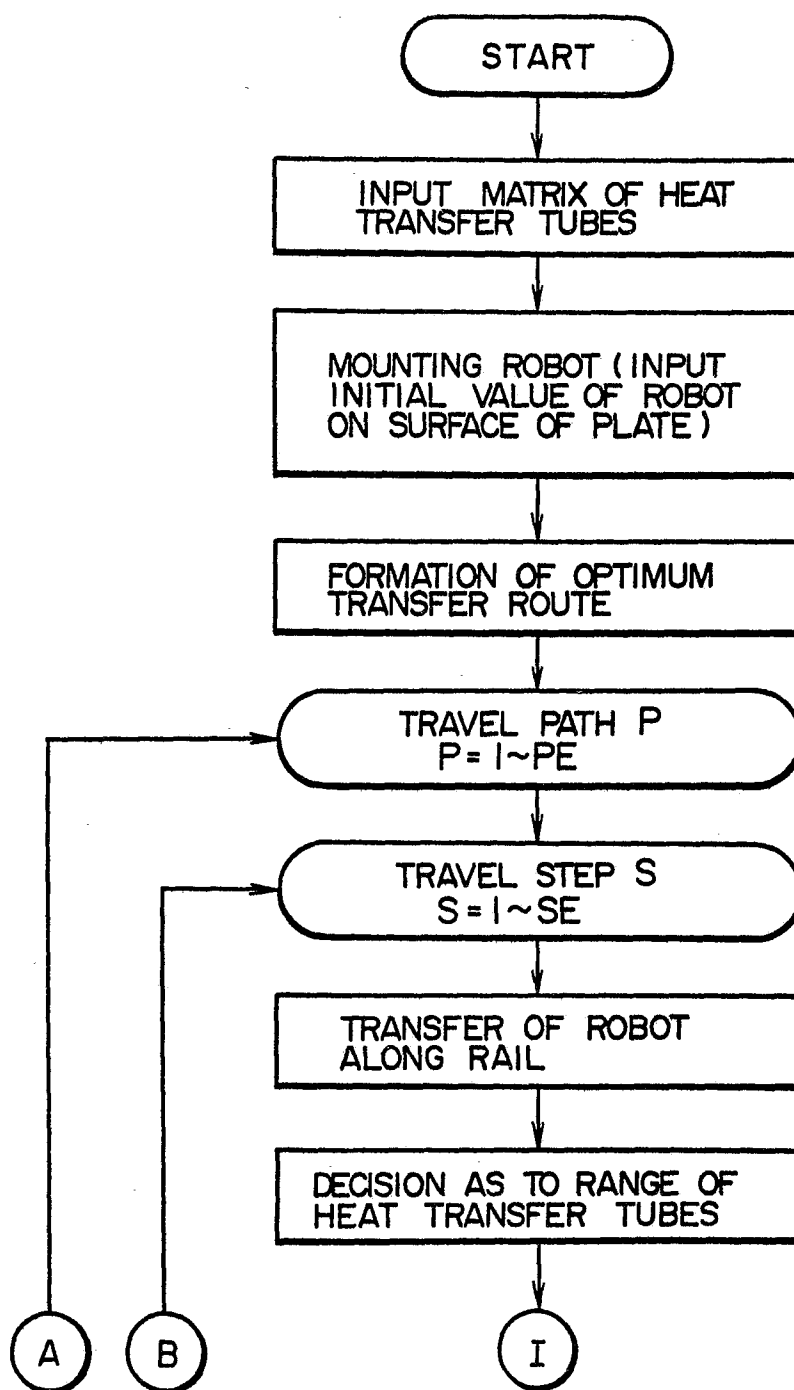


FIG. 16

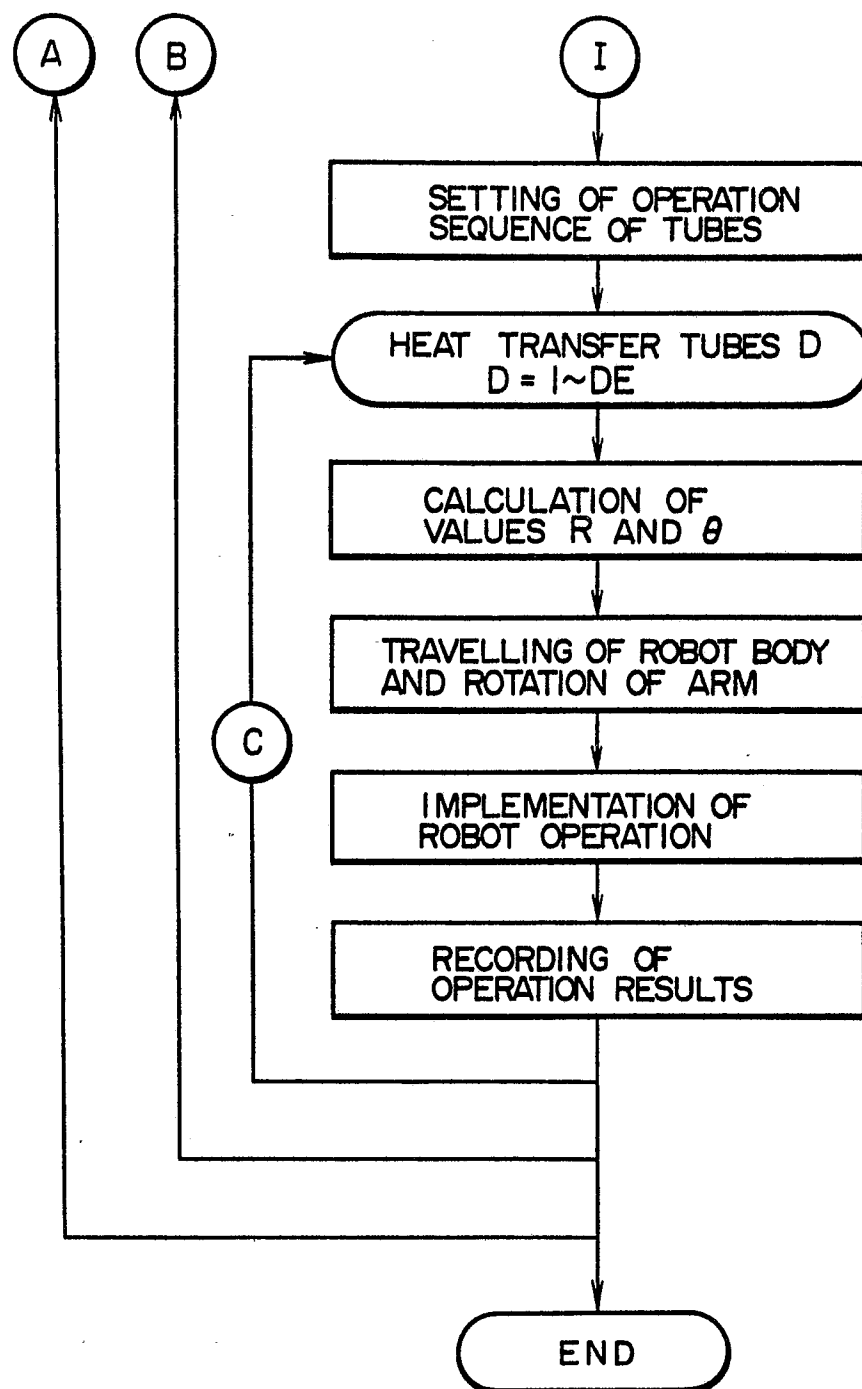


FIG. 17A

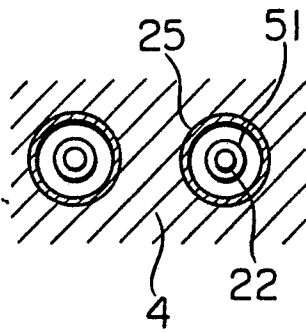


FIG. 17B

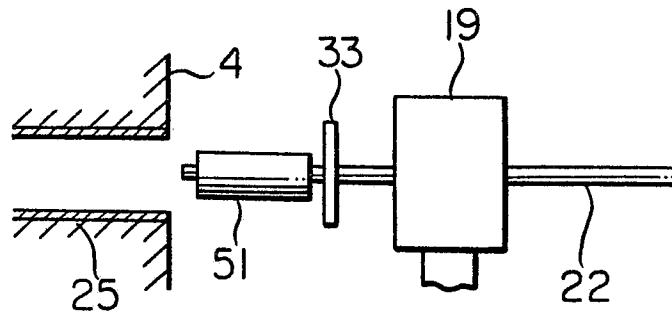


FIG. 18

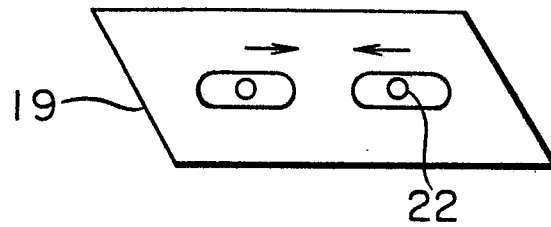


FIG. 19

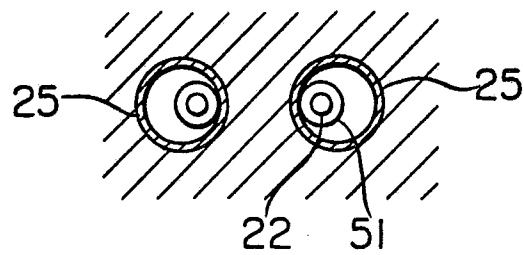


FIG. 20

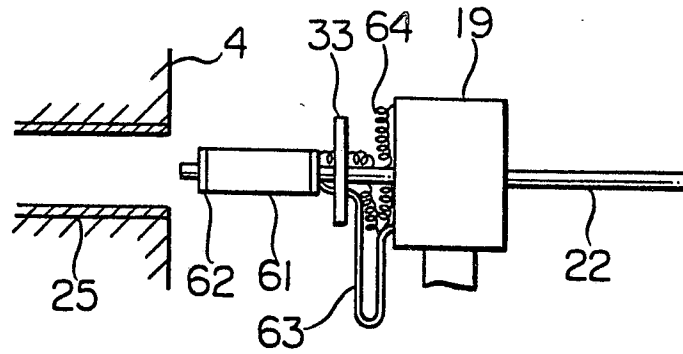


FIG. 21

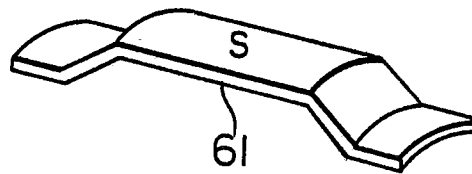


FIG. 22

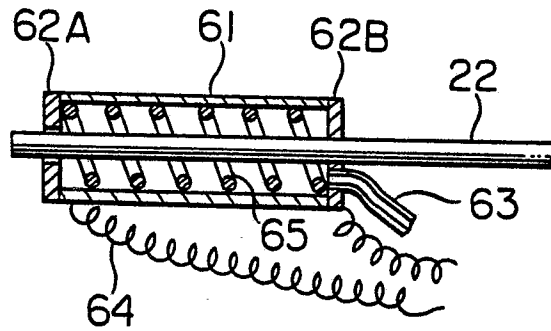


FIG. 23

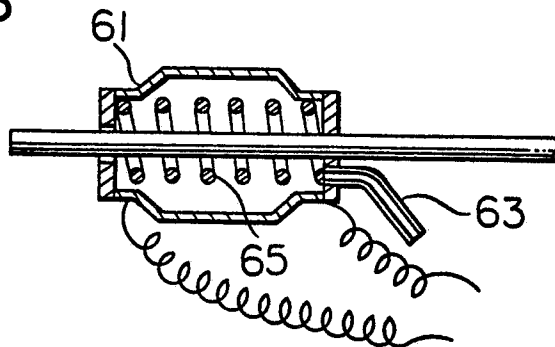


FIG. 24

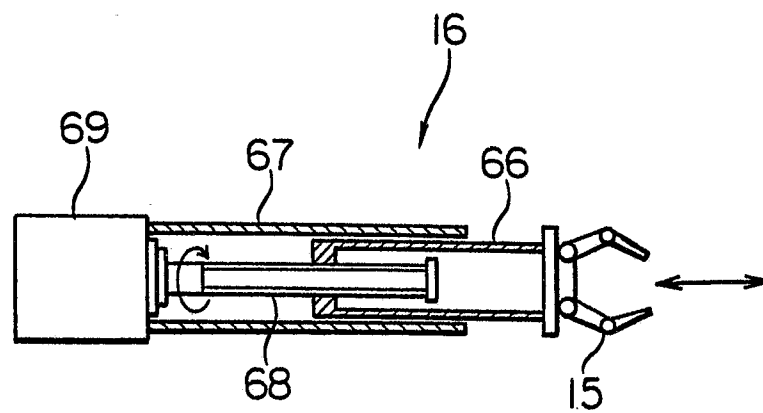


FIG. 25

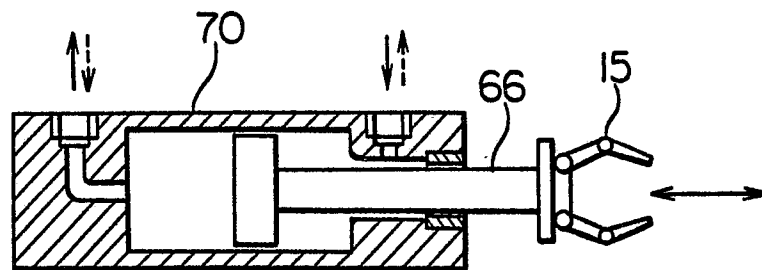


FIG. 26

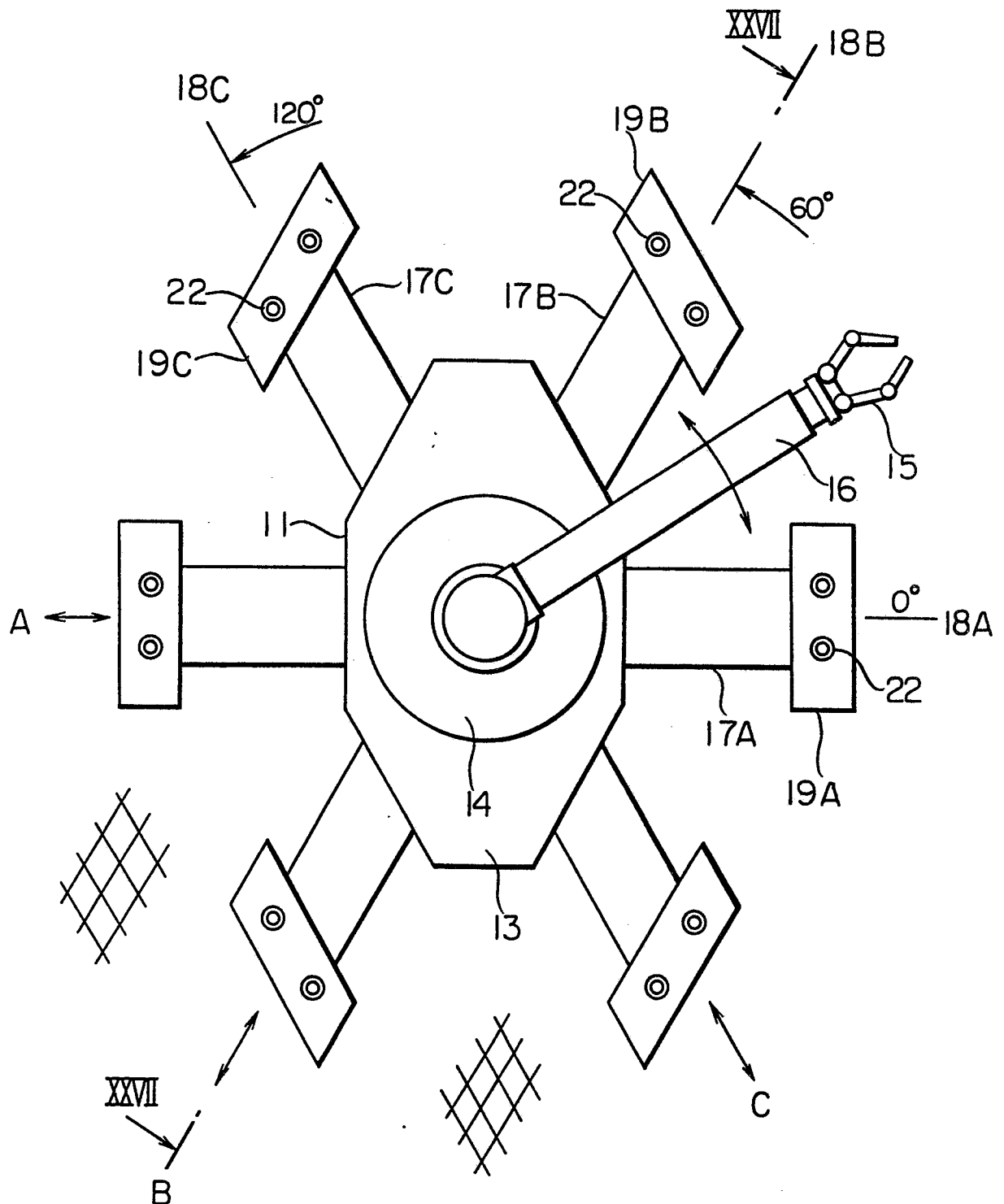


FIG. 27

