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(54) A heating unit.

(57) A heating unit for heating great amounts of flowing gas, such as a process gas to be heated to a temperature of about 300–500°C, e.g. for drying products.

The heating unit consists of a number of units mounted in side by side relation and each comprising a great number of series connected heating wires (16) suspended in a frame mounted in the flow duct of the gas and adapted to apply its high voltage of from 1 to 36 KV, the series connected heating wires having such a resistance that an effect of not less than 1/2 MW is dissipated in the plant. As a result a heating unit is obtained which compared to its output is encumbered with exceptionally low costs of construction and operation, particularly in areas with an inexpensive electricity supply due to water power.

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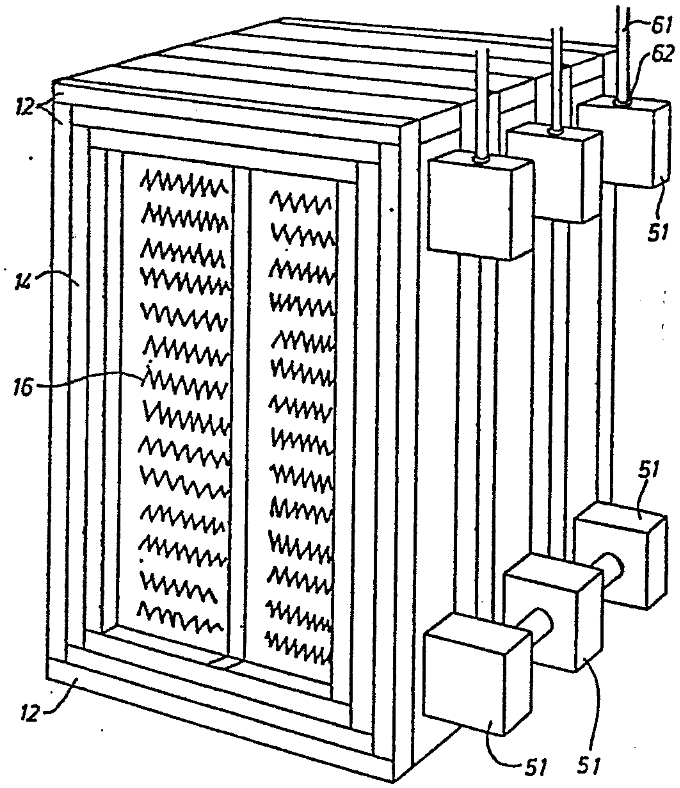
Fig.1



Title: A heating unit.

The invention relates to a heating unit for heating a gas, in particular a process gas passed through the unit.

Extremely high power, e.g. up to 10-15 MW, is sometimes required for hot-air heating, i.a. in connection with chemical processes, by means of which a gas is to be heated to 300-500°C, e.g. for drying; this procedure is difficult and expensive in construction as well as in operation.

It is the object of the present invention to provide a heating plant capable of heating very large amounts of a process gas at the same time while the costs of construction and operation are lower than previously known in connection with plants of this type.

According to the invention the heating unit comprises a great number of units mounted in side by side relation, each unit comprising a great number of heat wire coils connected in series and suspended in a frame mounted in the flow duct of the gas, and to which a voltage of 1 to 36 KV is applied during operation, the series-connected heating wires having such a resistance that a power of not less than 1/2 MW in the heating unit is dissipated. The plant is preferably dimensioned for a power of at least 1 MW with a supply voltage of about 10 KV. The fact that a high voltage, e.g. a three-phased supply line of about 10 KV or optionally about 30 KV, is available in connection with the remaining part of the industrial plant, is utilized in the inventive plant. Especially in countries with an inexpensive electricity supply due to the development of water power it will be possible to keep the working costs at a low level by using a plant according to the present invention.

The series connected heating wires may according to the invention be mounted on ceramic tubes suspended in an inwardly and outwardly insulated frame of an electrically conducting material, which floats electrically on an unknown potential, the potential not being electrically connected to anything else. As a result the high voltages on the heating wires are thus shielded. The electrically floating frame is preferably surrounded by an outer insulation again surrounded by an outer earthed frame. An electrically conducting rail is preferably embedded in an insulating layer between the frame of two units, said rail being connected to the floating neutral point of the heating unit; this connection is, however, monitored by a current transformer connected to a measuring device for registering a leakage current, if any. It is hereby made possible to monitor the construction and, if occassion should arise, intervene before an optional leakage current causes serious damages. The heating wires may furthermore advantageously be monitored by pyrometers in order to disconnect the current to the heating wires, if the wire temperature should exceed a given allowable value of e.g. 500 to 700°C.

The invention further relates to a terminal box for supplying high voltage to a heat wire coil. The heating plant is preferably built of three units mounted in side by side relation and each comprising a heating wire to be connected to a phase each in a star connection. In this manner an expedient compact unit is obtained simutaneously with the three-phased power supply being utilized. In view of the possibility for inspecting the plant it must be possible to disassemble each unit and thus each phase separately, and the construction consequently requires a terminal box for each phase wire and each neutral wire for each unit. It will consequently be a problem to fulfill the safety requirements of the power current regulations. The nominal safety distance at 10-12 KV is 11 cm. This distance cannot be obtained by the compact construction desired for the gas heating unit. An air gab of 11 cm corresponds to the fact that the equipment must be able to pass a surge voltage test at 75 KV. It is consequently a further object of the present invention to provide an unusually compact terminal box, which is nevertheless capable of passing a surge voltage test at 75 KV. This object is obtained by cooling means being provided in the terminal box according to the invention, and by field distributing plates being provided on both sides of the conducting means; as a result these field distributing plates extend to a considerable extent beyond the extension of the conducting means and are substantially located approximately in the centre of the air gabs between the conducting means and the closer metallic plate walls of the surrounding terminal box, and where furthermore all connections of conducting means are spherical. As a result a dispersal of all fields is obtained, and simultaneously the cooling ensures a suitably high breakdown voltage.

The invention will be described more detailed below with reference to the accompanying drawing, in which

Figure 1 is a perspective view of an example of a plant according to the invention,

Figure 2 is a front view of the plant of Figure 1,

Figure 3 is a sectional view through the plant along the line A-A.

Figure 4 is a front view of an example of a cassette for the plant of Figure 1,

Figure 5 is a side view of the cassette of Figure 1

Figure 6 illustrates an example of a heat wire winding for the plant,

Figure 7 is a diagram of a preferred wiring of the heat wires in a single cassette,

Figure 8 is a diagram of a preferred wiring for a plant comprising three cassettes,

Figure 9 is a side view of an example of a terminal box for a phase conductor,

Figure 10 is a front view of the box of Figure 9,

Figure 11 is a top view of the box of Figure 9,

Figure 12 is an example of a pressure-proof feed-through of a phase supply line,

Figure 13 illustrates a feed-through of the conducting rod means, and

Figure 14 illustrates an example of a terminal box for a neutral conductor.

The heating unit illustrated in Figure 1 is formed as a duct passed by the process air to be heated. The duct is thermally and electrically insulated. On the outside the heating unit comprises an outer rectangular frame 12, e.g. of steel sections. Within said frame there are two layers of ceramic blocks 14, e.g. of skamol. Three so-called cassettes 20 with a row of serially connected heat wires each are located in this insulated shell. A cassette is built up of a frame 22, which on the inner side is coated with insulating ceramic blocks, preferably skamol, type V 1100. The electrical as well as the thermal insulating capacity is of essential importance in this construction. The frame 22 consists of two rectangular steel sections connected to transverse sections in each corner. On the narrow vertical sides cross pieces 32 are mounted, which are used as suspension for a number of ceramic tubes 26 optionally built up of two tubes, innermost a tube of type 710 according to DIN 40685, e.g. alsint® 99.7 with a great mechanical strength and capable of resisting breakdowns at an operating voltage of 10 KV and a temperature of 800°C. Round and concentrical with the alsint tube a tube of type 530 may be provided after Silimanite® 60 tubes capable of enduring great variations in temperature. This tube ensures an equalization of temperature compared to the alsint tube.

The ceramic tubes 26 carry the heat wires. The heat wires may be of any common resistance material, but a nickel alloy, Ni 80, e.g. of the brand "Kantal" is preferred, and the coils can advantageously form an almost star-shaped pattern as illustrated in Figure 6, which illustrates an end view of such a heat wire coil. Many similar coil patterns may obviously be used fulfilling the two necessary conditions, viz. that the coil can be firmly fixed round a tube and furthermore is capable of emitting its heat as efficiently as possible to the ambient passing air. Such coils are i.a. described in DE Patent Specification No. 28 50 111. Oxydized heat wires are preferably used, which are consequently surface insulated to some extent.

Two vertical "columns" separated by an intermediate wall 70 are provided in a preferred embodiment of a typical cassette, each column comprising e.g. fourteen tubes 26 wound with a heat wire. The individual heat wire elements are connected by heavy connecting wires or bars. All heat wire elements in a cassette are, however, preferably substantially formed by a continuous heat wire, which on the spots where the wire passes through the intermediate wall 70, are connected in parallel with a suitably thick additional heat wire in order to reduce the heat emission in the place concerned. A preferred coil arrangement is illustrated in Figure 7, where the coils are, however, only indicated.

A rod 30 forms the supply line to the heat wire coil. The rod passes through the insulation 24 of skamol and the frame 22. In order to avoid voltage breakdown from the supply line rod 30 to the frame 22 and the suspensions 32 connected to the frame, the supply line 30 is surrounded by a toroide 34 ensuring an even field distribution around the supply line.

The three cassettes 20 are preferably situated in side by side relation in such a manner that each cassette is connectable to one of the phases of a three-phased high-voltage system e.g. having a rated voltage of 10 or 30 KV. The coils are star connected as illustrated in Figure 8, and the upper supply lines are preferably connected to the phase conductors, and the lower supply lines are together connected to the neutral conductor. As a result of this arrangement the voltage level in the upper part of the construction is at about 10 KV or whatever high voltage chosen, and from there it drops evenly down to 0 volt in the bottom of the unit. There are only small differences in voltages between the individual coils. There are, however, great differences in voltage between two filaments in two neighbouring frames, especially at the top, and the frames are consequently located at a certain mutual distance and with intermediate insulation as illustrated in Figure 3.

When constructing the unit each mounted cassette is inserted on rollers or balls on a rail 50 each in the bottom of the unit which is then closed by the outer insulation 14.

An electric diagram of the heating unit is illustrated in Figure 8. The heat wires 40 are in one end connected to a phase R, S, T, each, and in the other end they are interconnected. The boxes 42 are a symbol of the resistance in the inner insulation between the steel frame 22 and the heat wires 40. The conductor 22 represents the steel frame itself, which in the ideal case will be voltage-free. The boxes 44 represent the resistance in the outer insulation on the outside of the steel frame 22 of the cassette. The outer insulation 14 is secured by the outer frame 12, which is earthed.

In principle there are thus two independent insulation systems with separate insulation resistances symbolized by the resistances 42 and 44. The three inner frames 22 form three shells, which in respect to voltage are floating mutually as well as in relation to earth. Floating means no interconnections, and the voltage difference may assume any value.

The part of the construction most exposed to fault currents will be the upper part of the innermost insulation, the great differences in voltage being present in the upper part of the construction. Furthermore, the inner insulation will during operation be heated vigorously, and this heating will reduce the electrically insulating capability.

A leakage current from phase to phase has to pass three leakage paths, L1, L2, L3, wherein L1 lies in the inner frame insulation 24, L2 is the insulation 46 between the frames mutually, and L3 is the inner insulation 24 in the second frame. In the plant illustrated in the drawing L1 = L2 = L3 = 20 cm, i.e. the total leakage path is 60 cm. Furthermore the leakage paths are situated in three different places in the construction. The division into three leakage paths situated in three different places in the construction renders it very unlikely that the conditions of forming a voltaic arc will be present in all three places simultaneously.

There will also be a certain risk of a breakdown from phase to phase between two heating wires. The air distance between the heating wires in two different phases is 30 cm in the illustrated plant, as it appears from Figure 3. This distance must of course be dimensioned in consideration of the type of the process gas and the temperature of the gas in the plant to be manufactured as well as of the high voltage applied.

A metal rail X can advantageously be embedded in the insulating layer 46 between the frames, said rail being connected to the internal floating "neutral" point of the heating surface. It will then be possible by means of a current transformer to register an incipient leakage current between the phases. Such a leakage current could be caused by a smudging of the insulating material.

A set of terminal boxes belongs to the heating unit as illustrated in Figure 1. The high voltage is supplied to one of the heat wire coils through the upper three terminal boxes 51, and the other end of the heat wire coils is connected to a common floating neutral point through the three lower terminal boxes in such a manner that the star connection illustrated in Figure 8 is achieved.

Figure 9 illustrates a terminal box 51 for a phase conductor 30 passing through the side wall of the heating unit through the insulating layers 14, 24. The phase supply lines 61 are supplied from the top through an insulating suspension 62 and through a further insulator 66. The supply line 61 is connected to the conductor 30 in a globe 55 placed approximately in the center of the terminal box. The feed-through into the terminal box of the conductor 30 is passed through a number of insulating plates 60, cf. Figure 13, which is preferably made of silicone rubber with an ϵ_r of about 2. A laminated construction is applied consisting of several plates, which are glued together.

The conductor 30 is further provided with a series of cooling fins 52, e.g. of alumina, as illustrated in Figures 9 and 11. These cooling fins are to keep down the temperature in the conductor 30, as it must be borne in mind that the conductor 30 originates from a vigorously heated area.

Both the conductor 30 and the cooling fins 52 as well as the globe 55 are on both sides surrounded by insulating plates 54, e.g. of Etranox, and preferably of Etronit No. 1. The plates are suspended with no conducting connection to anything else. A field distribution from the conducting high-voltage supplying parts is obtained by means of these plates.

The terminal box 51 is closed at the front by means of a lid 54. On its rear side 65 the lid is provided with ducts for cooling air to keep a suitably low temperature of the air in the terminal box. This is very essential as the breakdown voltage of a gas is very dependent on the temperature. The lowermost terminal boxes for the neutral conductors correspond in principle to the terminal boxes described above, but the three terminal boxes are furthermore provided with feed-throughs allowing a coupling of the neutral conductors. The feed-throughs in the side of the terminal boxes are constructed according to the same principle as illustrated in Figure 13. Toroides are furthermore used in order to obtained a further equalization of the fields. A feed-through of the conductor 48 is provided in the terminal boxes of the neutral conductors, said feed-through connecting the electrically conducting measuring and monitoring rail X to the floating neutral point to enable a monitoring of the heating unit, so that a beginning leakage current will be registered quickly, and so that there is time for the high-voltage to be disconnected, in case a dangerous situation arises.

Claims:

1. An electrical high-voltage and high-power heating unit for heating a gas, in particular a process gas, passed through the unit, said unit comprising a number of units mounted in side by side relation, each unit comprising a great number of heat wire coils (16) connected in series and mounted on thermostable, preferably ceramic, tubes (26) suspended in an inwardly thermostable, insulated frame (22) of an electrically conducting material, c h a r a c t e r i s e d in that the frame floats on an unknown potential, the potential not being electrically connected to anything else, and that the electrically floating frame (22) is surrounded by an outer insulation (14), which is again surrounded by an outer earthed frame (12).

2. An electrical heating unit as claimed in claim 1, c h a r a c t e r i s e d in that voltage supply lines (30) to the heat wire coils (16) are surrounded by toroides (34) in the places, where the supply lines are passed through the outer (12) and the inner (22) frame.

3. An electrical heating unit as claimed in claim 1, c h a r a c t e r i s e d by comprising three or a multiple of three units, the heat wires (40) of which are star connected, i.e. in one end they are connected to a phase (R, S, T) each, and in the other end they are interconnected to form a common floating neutral point (0).

4. An electrical heating unit as claimed in claim 3, c h a r a c t e r i s e d in that in an insulating

layer (46) between the frames (22) of two units an electrically conducting rail (X) is embedded connected through a conductor (48) to the floating neutral point (0) of the heating unit, said conductor being monitored through a current transformer.

5. An electrical heating unit as claimed in claim 3 or 4, c h a r a c t e r i s e d in that a combination of leakage paths is provided comprising various different leakage paths in continuation of each other, which any leakage current will have to pass.

6. A terminal box, in particular for a high-voltage and high-power heating unit as claimed in one or several of the preceding claims, c h a r a c t e r i s e d in that cooling means are provided in the box, and in that field distributing plates (54) are provided on both sides of the conducting means (30), said field distributing plates extending to a considerable extent beyond the dimensions of the conducting means and being located substantially approximately in the centre of the air gabs between the conducting means and the closer metallic plate walls in the surrounding terminal box, and in that all connections of conducting means are spherical.

7. A terminal box as claimed in claim 6, c h a r a c t e r i s e d by a pressure-proof feed-through of the phase supply lines (61) being provided through the insulators (66, 62).

8. A terminal box as claimed in claim 6, c h a r a c t e r i s e d in that all feed-throughs in the walls of the terminal box are provided with toroides

along the edge of the wall in the plane of the wall side, and that the cavity between the conductor, led through the wall and the toroid-shaped termination of the wall towards the conductor, is filled with an insulating dielectric, non-conducting material with $\epsilon_r \simeq/ <2$.

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Fig.1

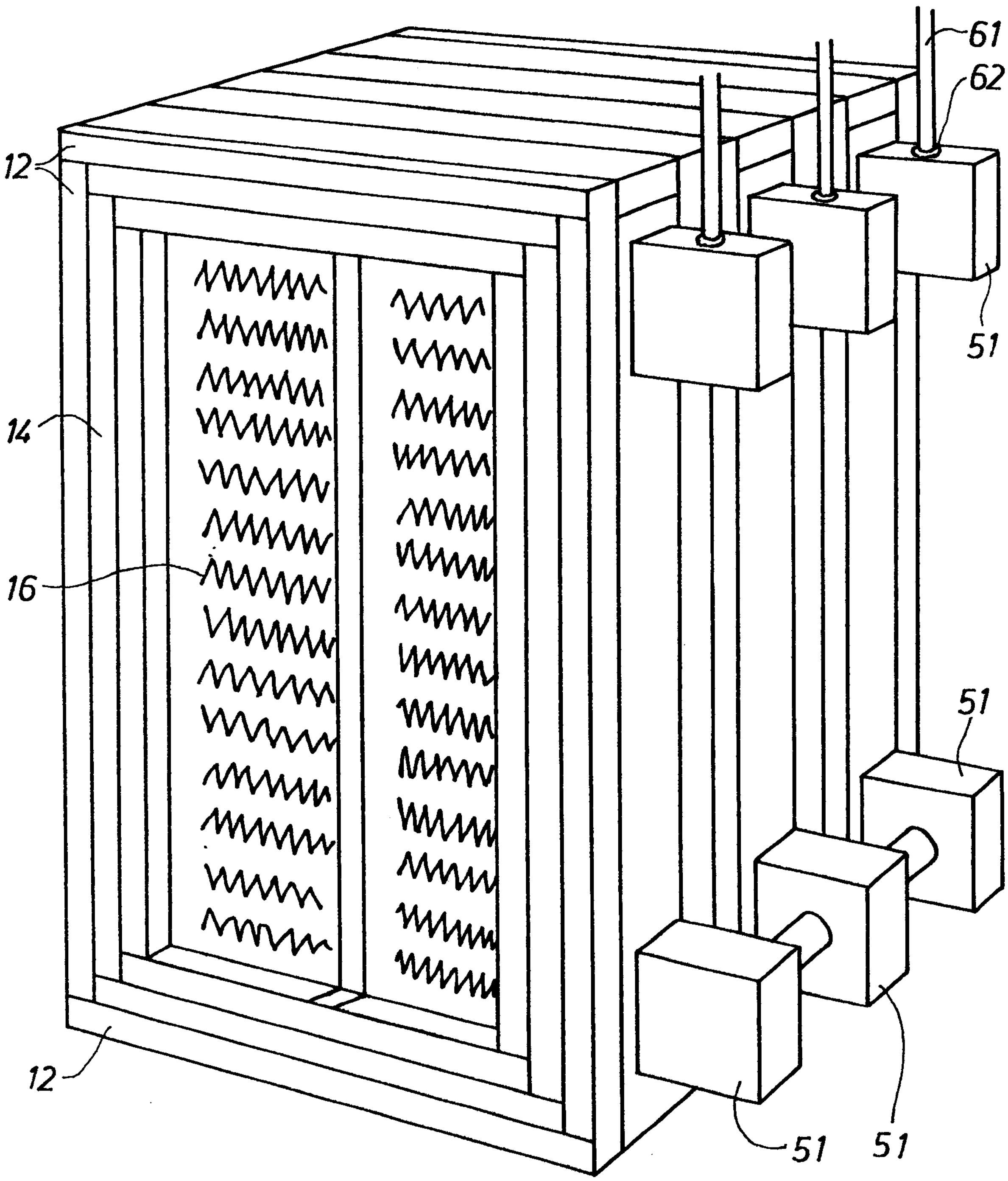

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Fig.2

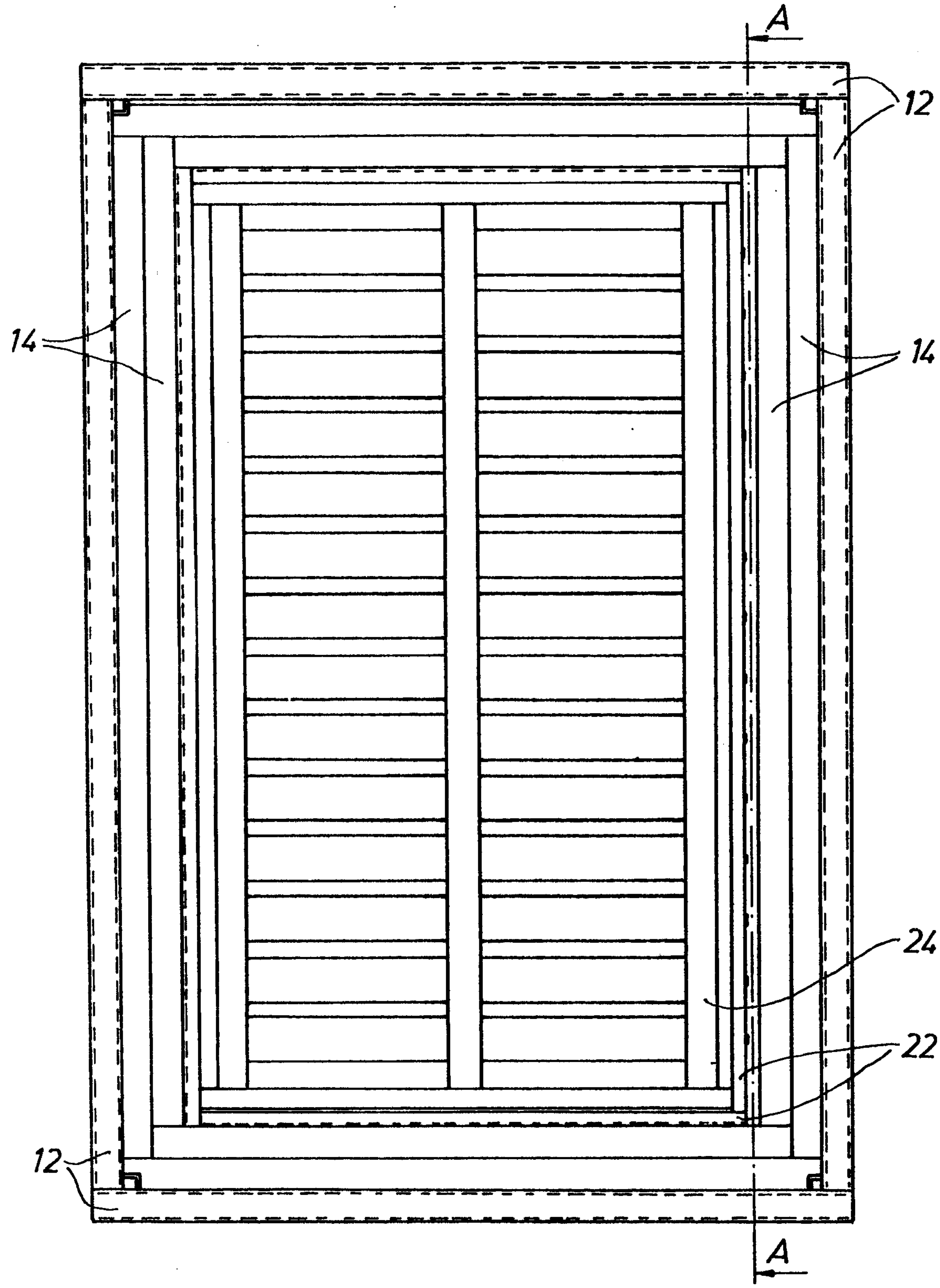
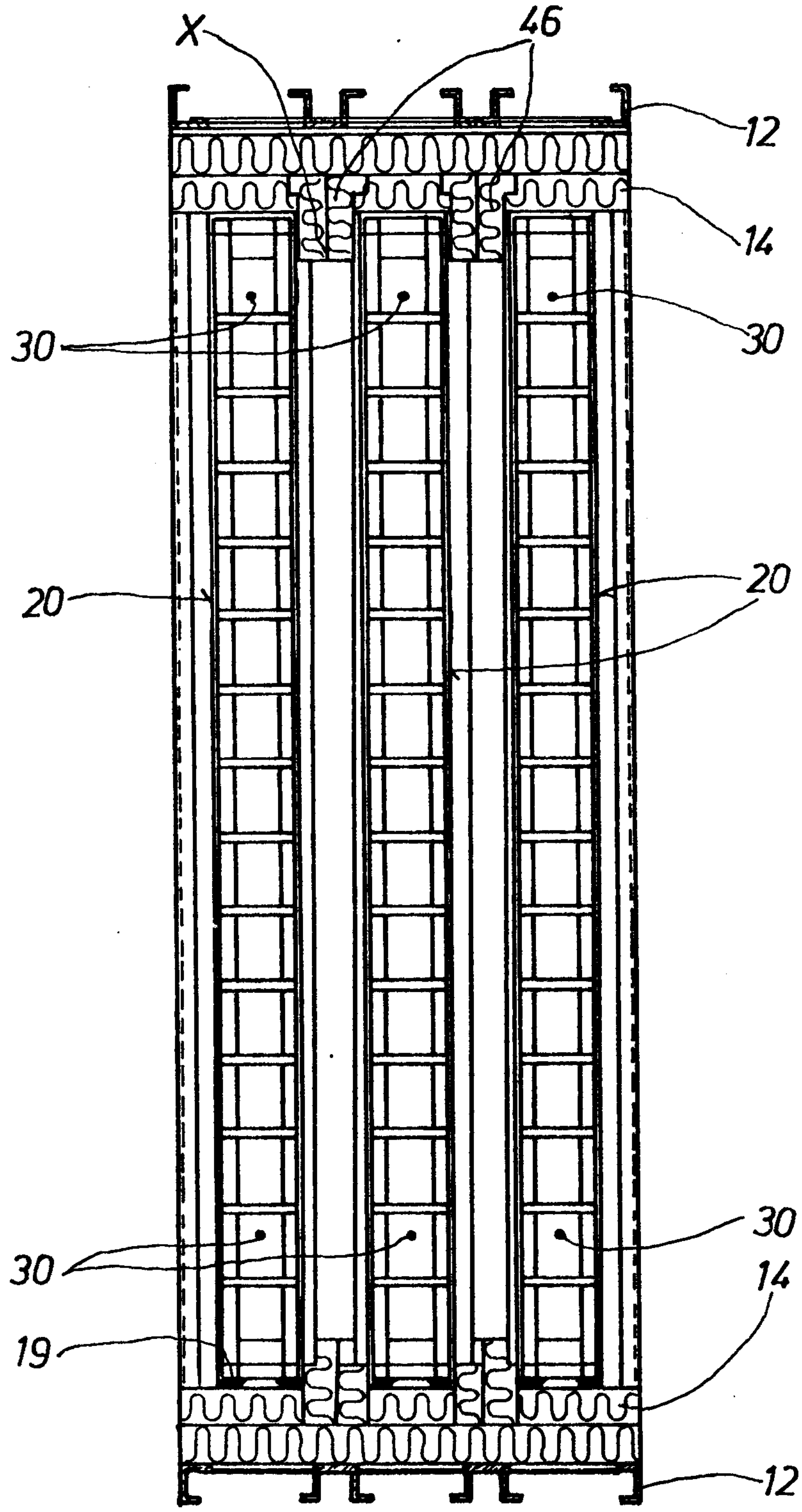


Fig.3



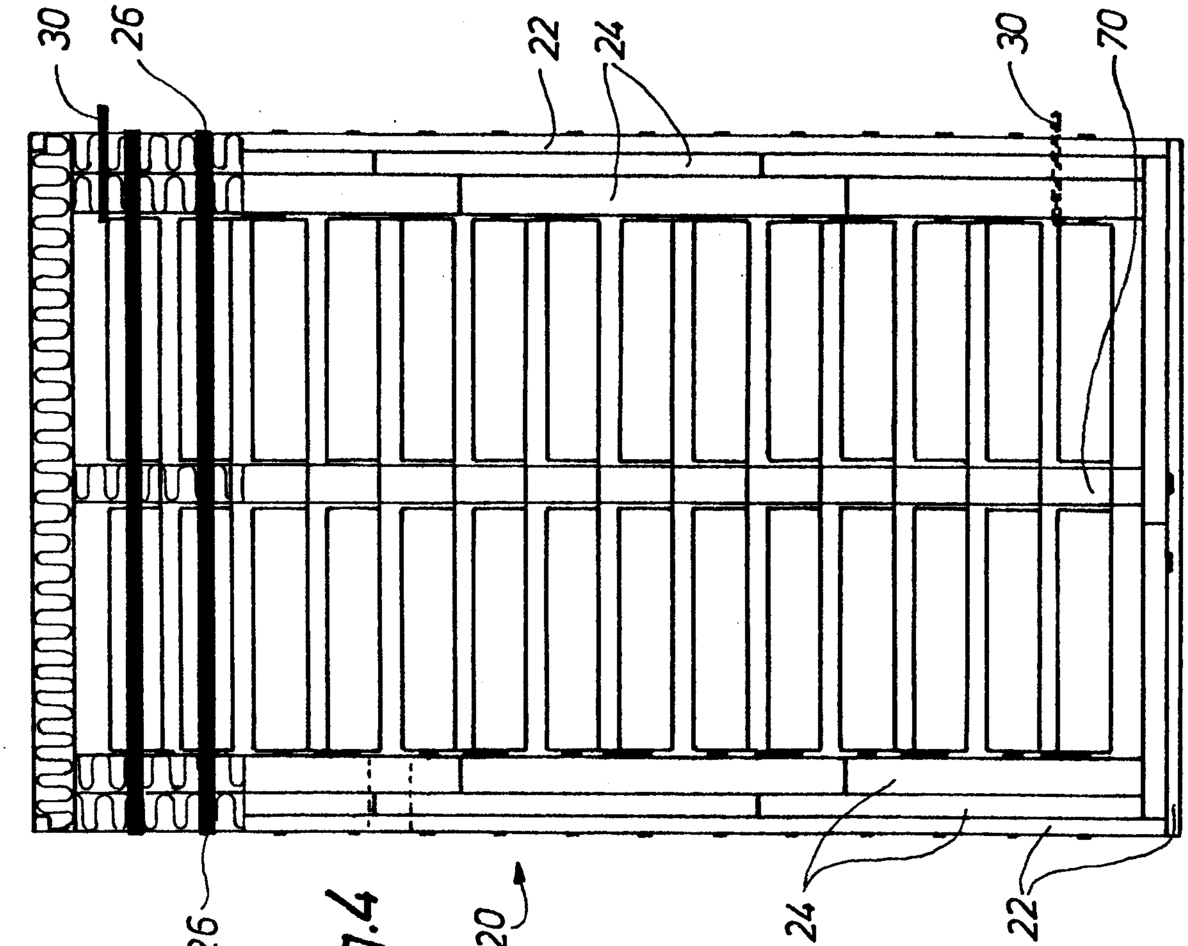


Fig.4

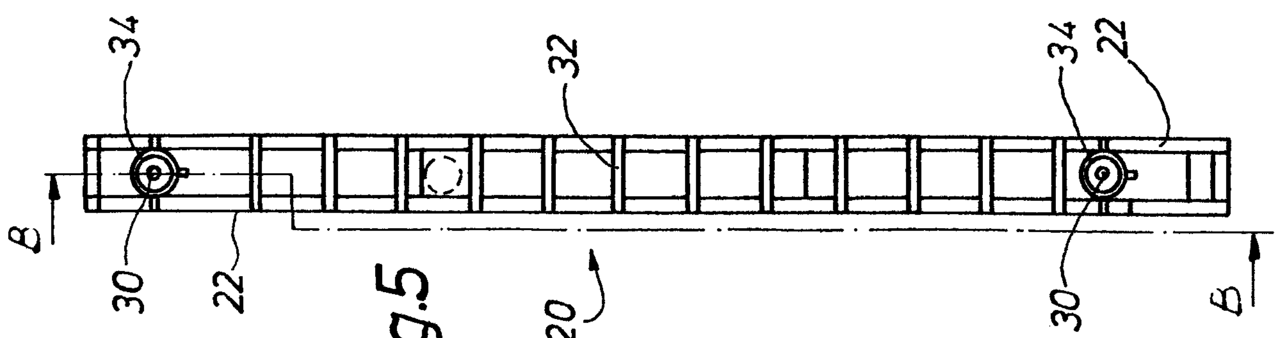


Fig.5

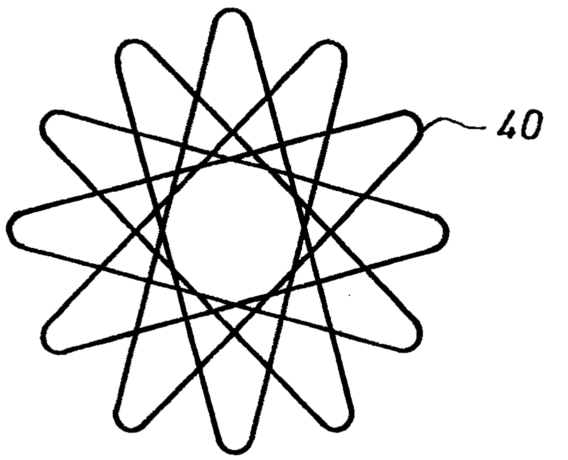


Fig. 6

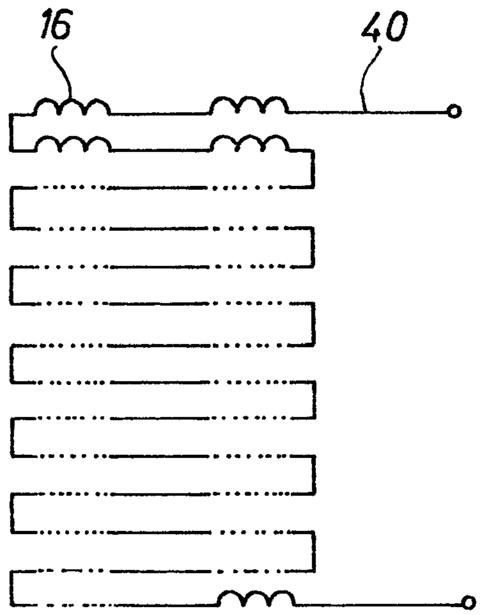


Fig.7

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Fig.8

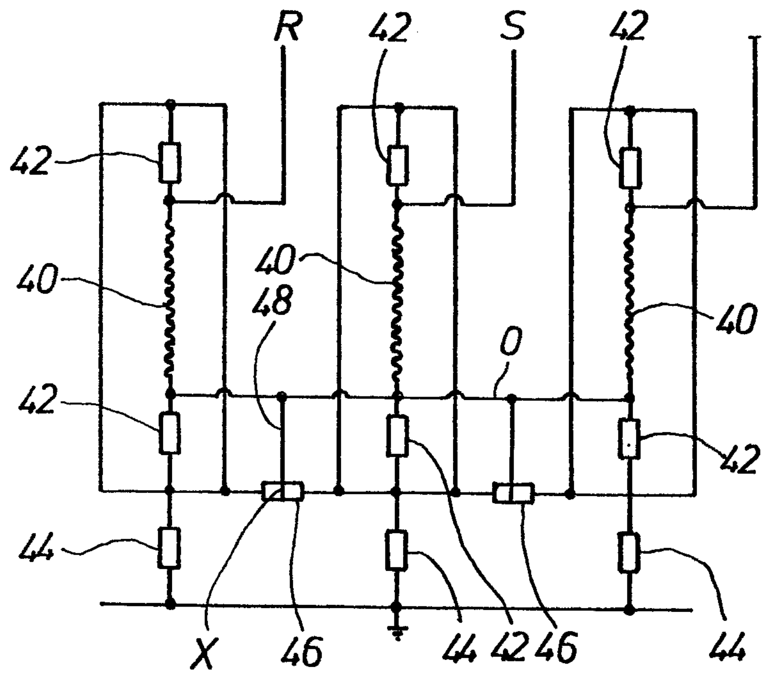

Fig.12

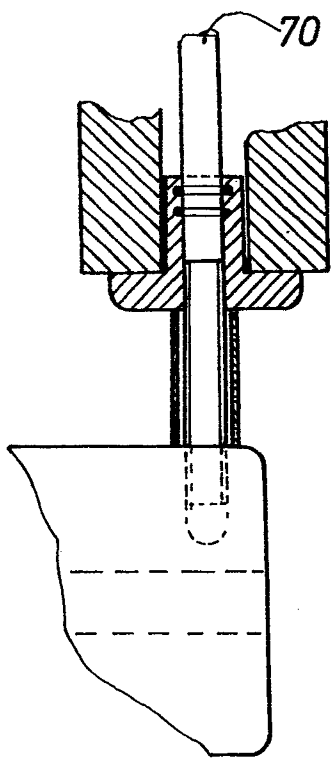

Fig.13

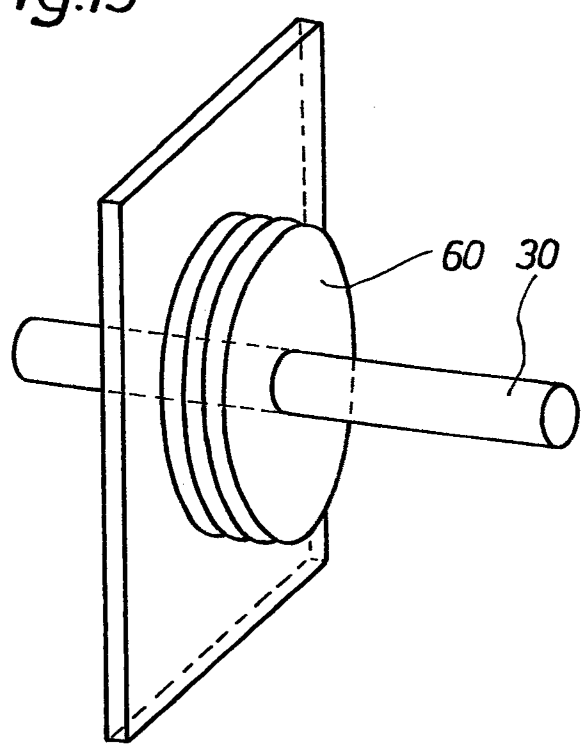

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Fig.9

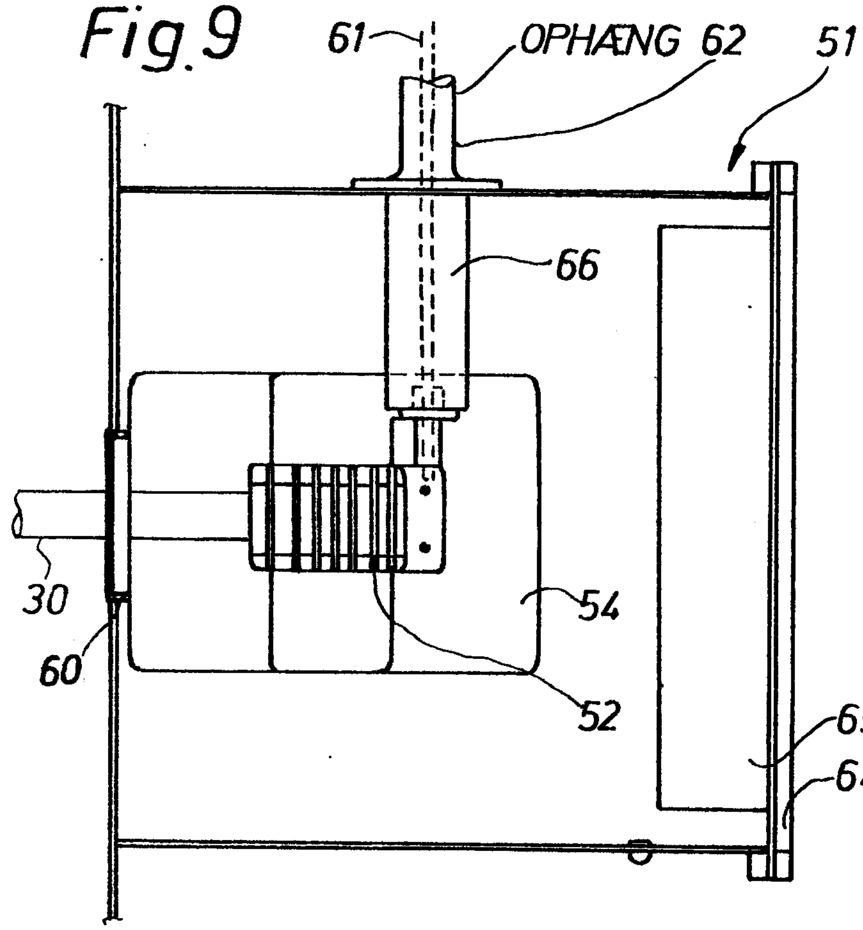


Fig.10

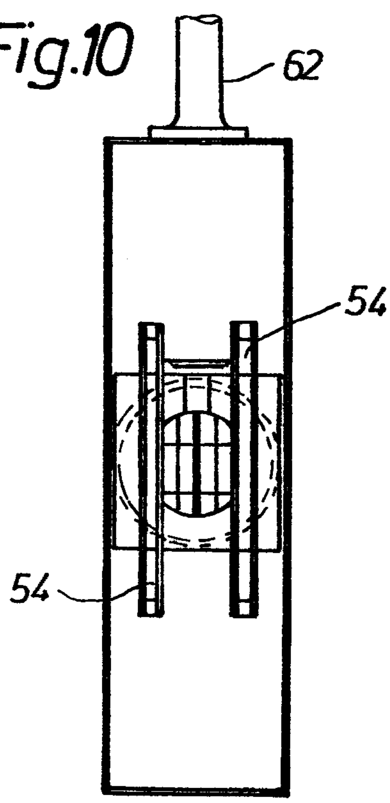
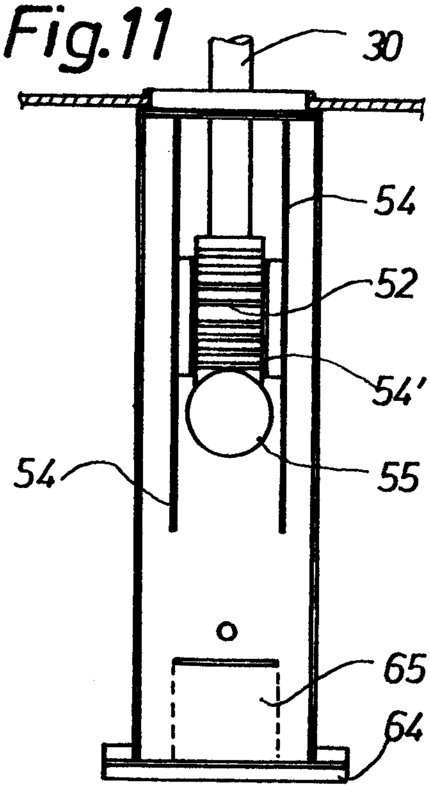


Fig.11



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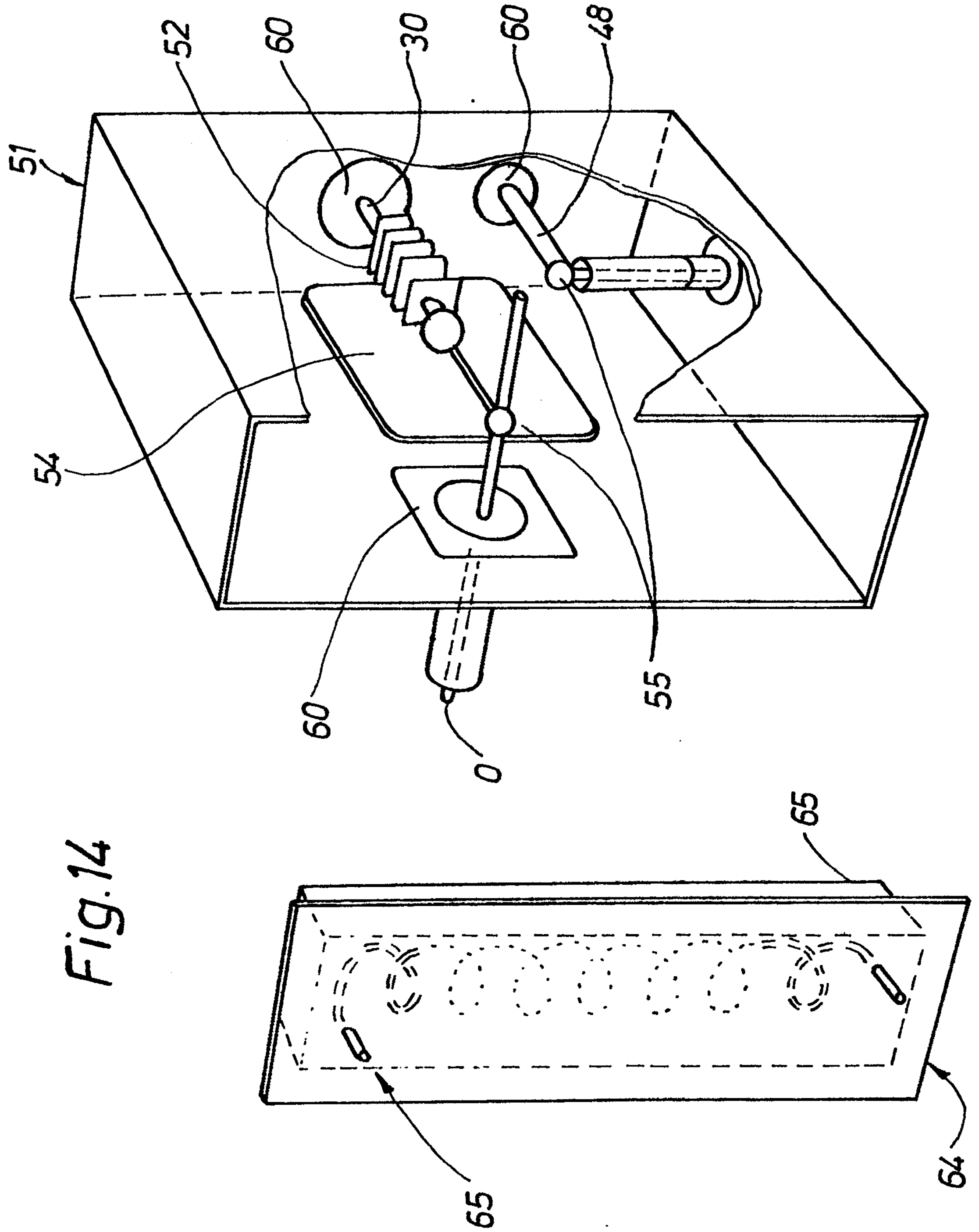

Fig.14

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EUROPEAN SEARCH REPORT

0208241

Application number

EP 86 10 8966

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)
A	US-A-4 337 390 (BEST) * Column 4, line 31 - column 5, line 48; figures 1,2,10,11 *	1,3	F 24 H 3/04 H 05 B 3/32
A	DE-A-3 326 463 (KOENN) * Page 7, last paragraph; page 8, paragraph 1; figure 1 *	1,4	
A	FR-A-1 008 918 (SOCIETE D'ETUDES MATERIEL ELECTRIQUE ET MECANIQUE) * Page 1, left-hand column, line 30 - right-hand column, line 23; figure 1 *	1,2,6,8	
A	US-A-2 868 944 (KOCH et al.)		
A	EP-A-0 099 825 (FIVES-CAIL BABCOCK)		
A	FR-A-2 511 208 (GIDROPROEKT)		

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

F 24 H 3/00
H 05 B 3/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15-10-1986	RAUSCH R.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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