Aug. 16, 1960 J. F. BELTON, JR., ET AL 2,949,014

THERMOELECTRIC AIR CONDITIONING APPARATUS

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Fig. 1.

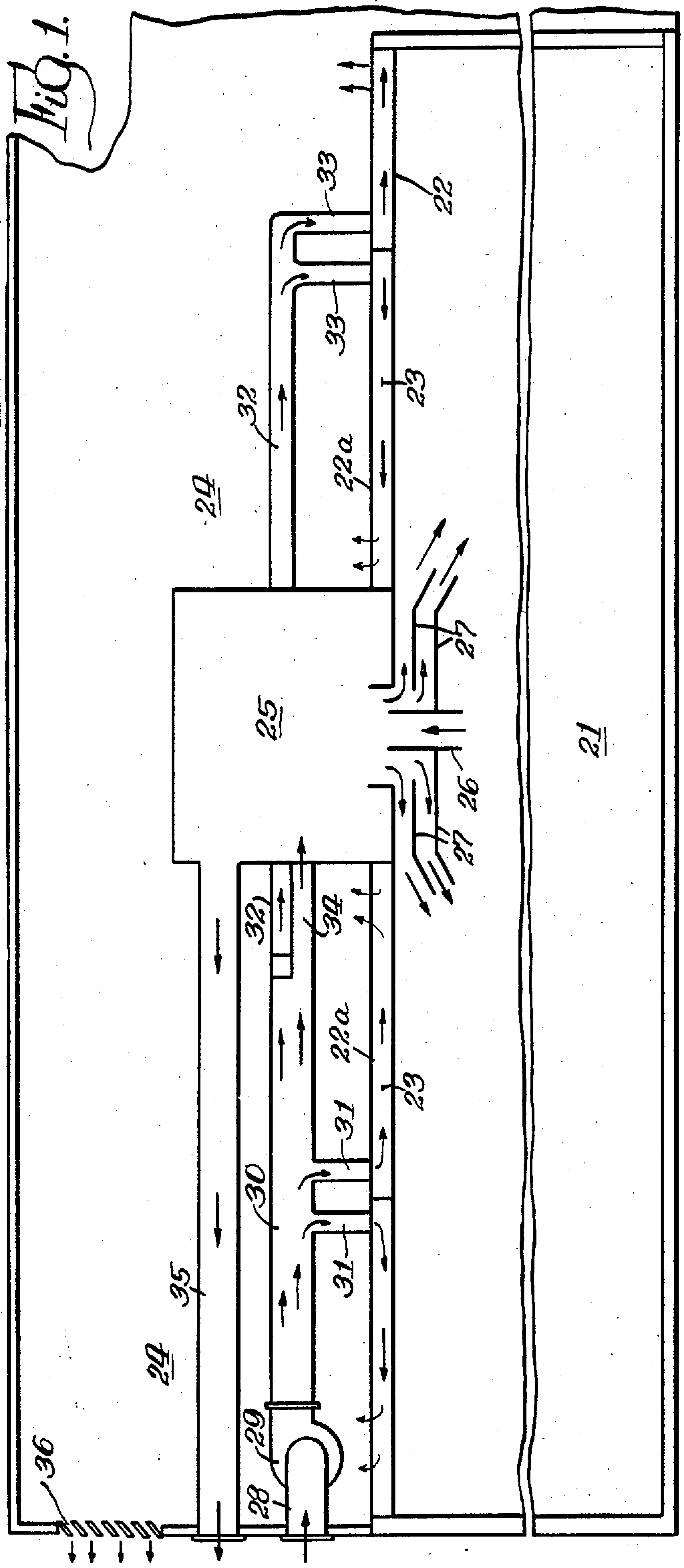
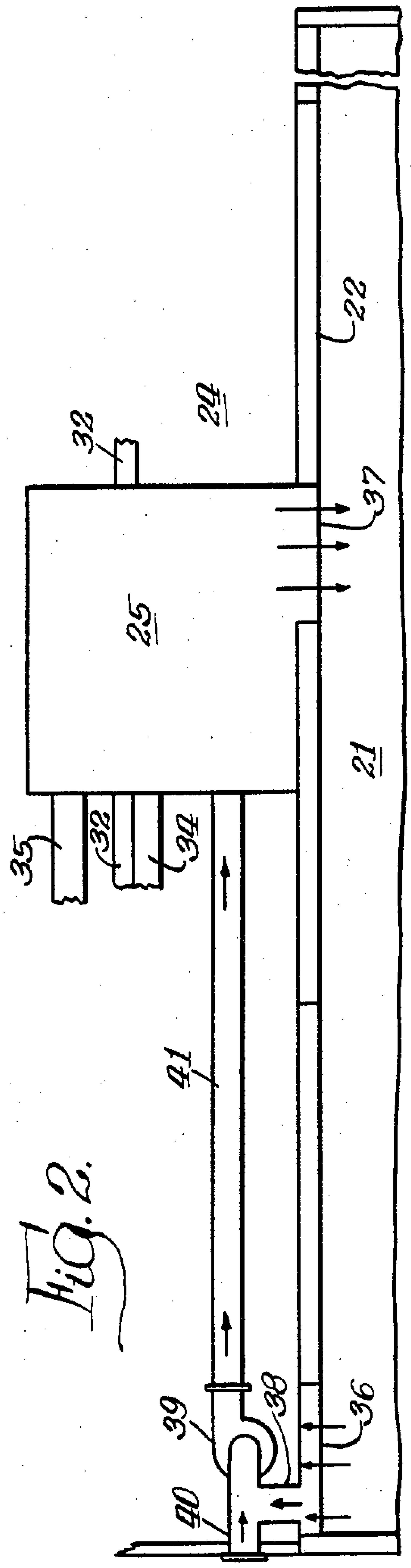


Fig. 2.



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THERMOELECTRIC AIR CONDITIONING APPARATUS

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Fig. 3.

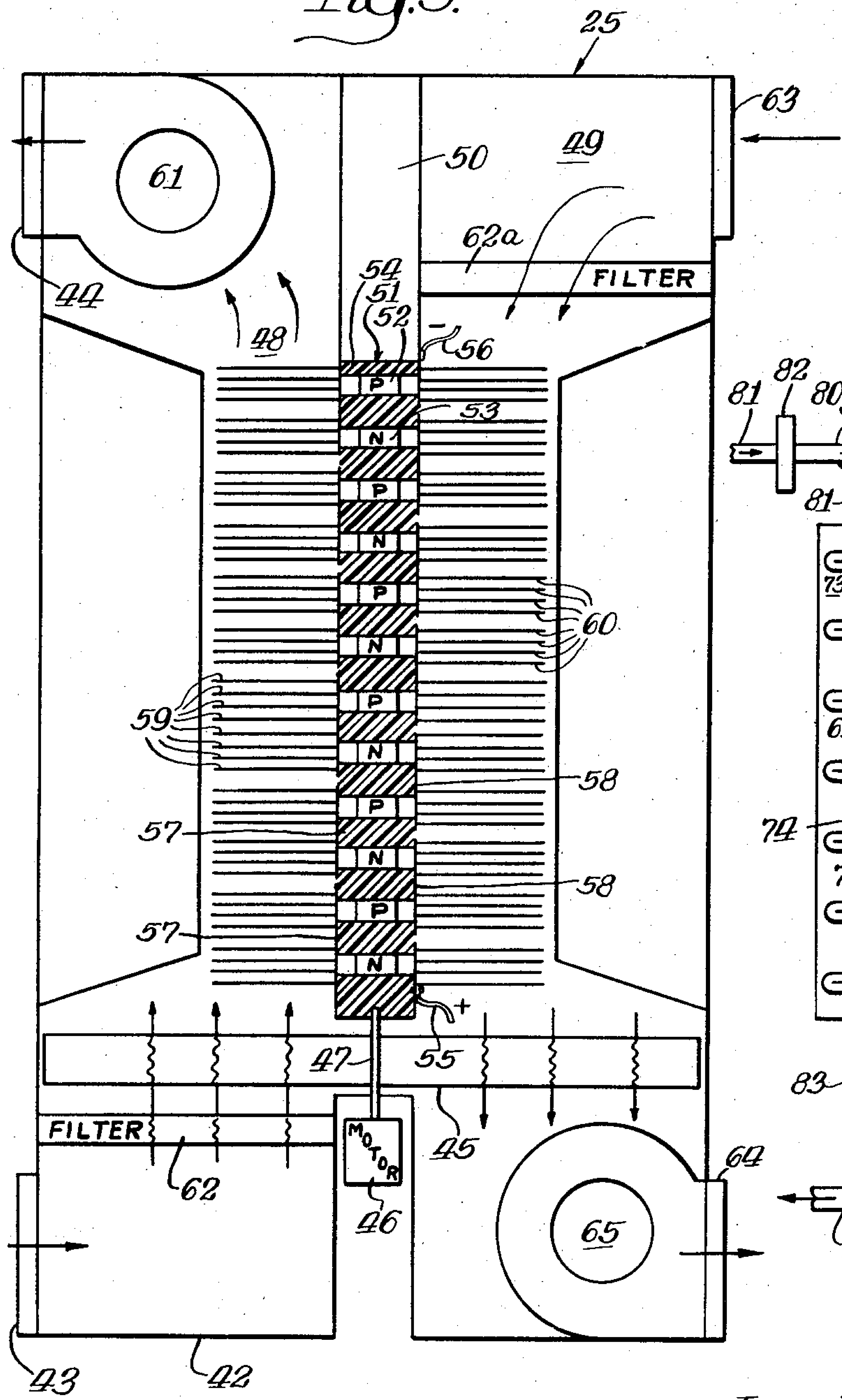
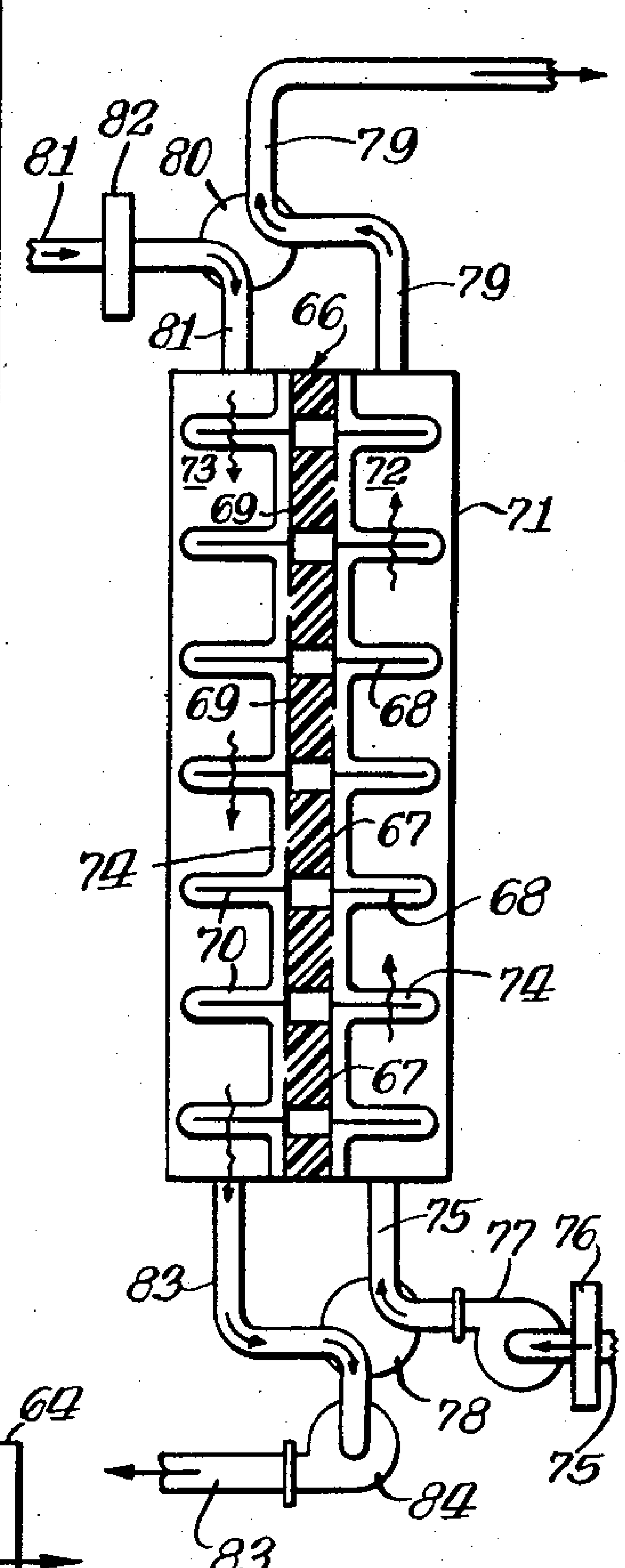


Fig. 4.



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THERMOELECTRIC AIR CONDITIONING APPARATUS

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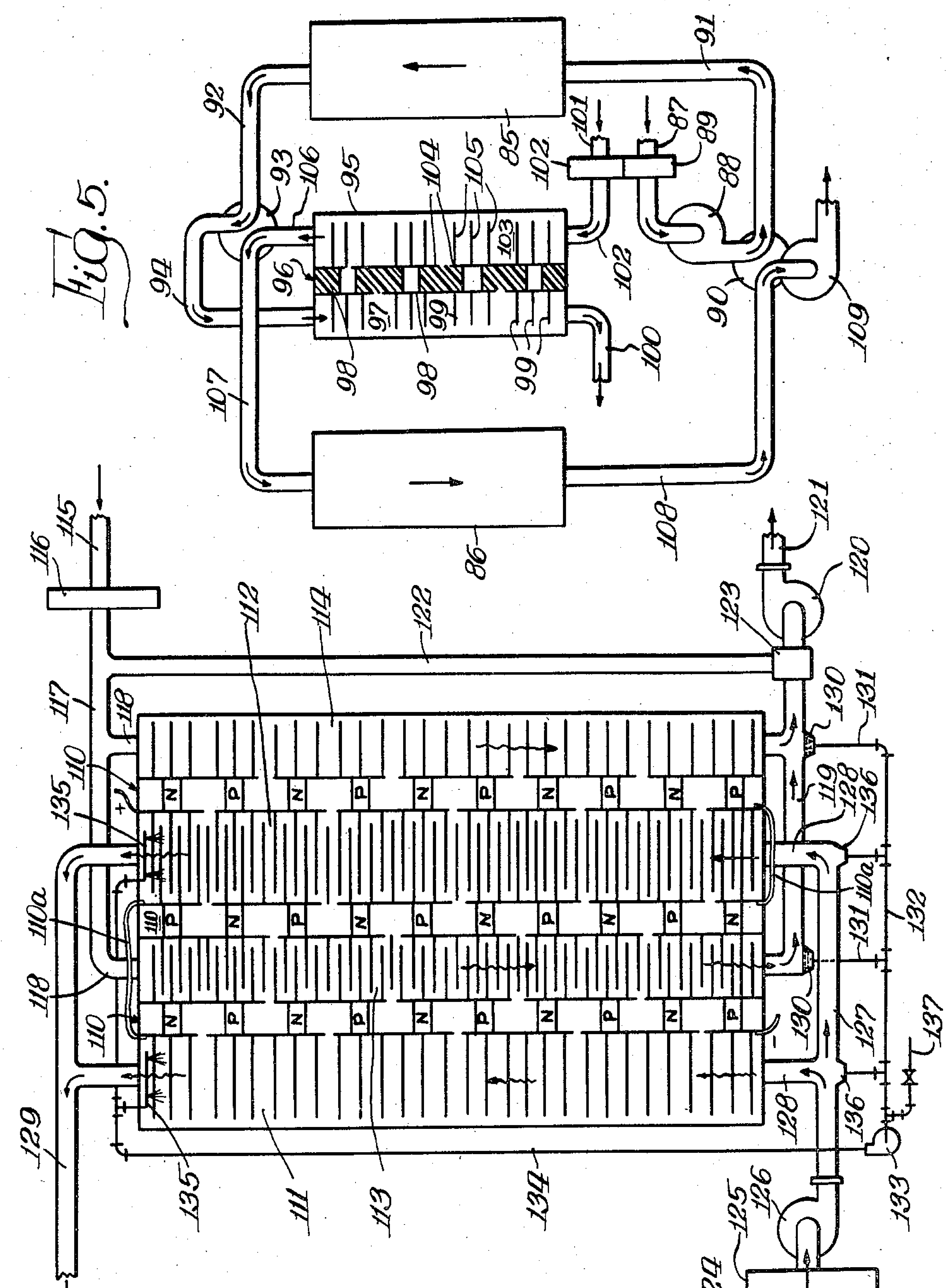

Fig. 5.

Fig. 6.

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Fig. 13.

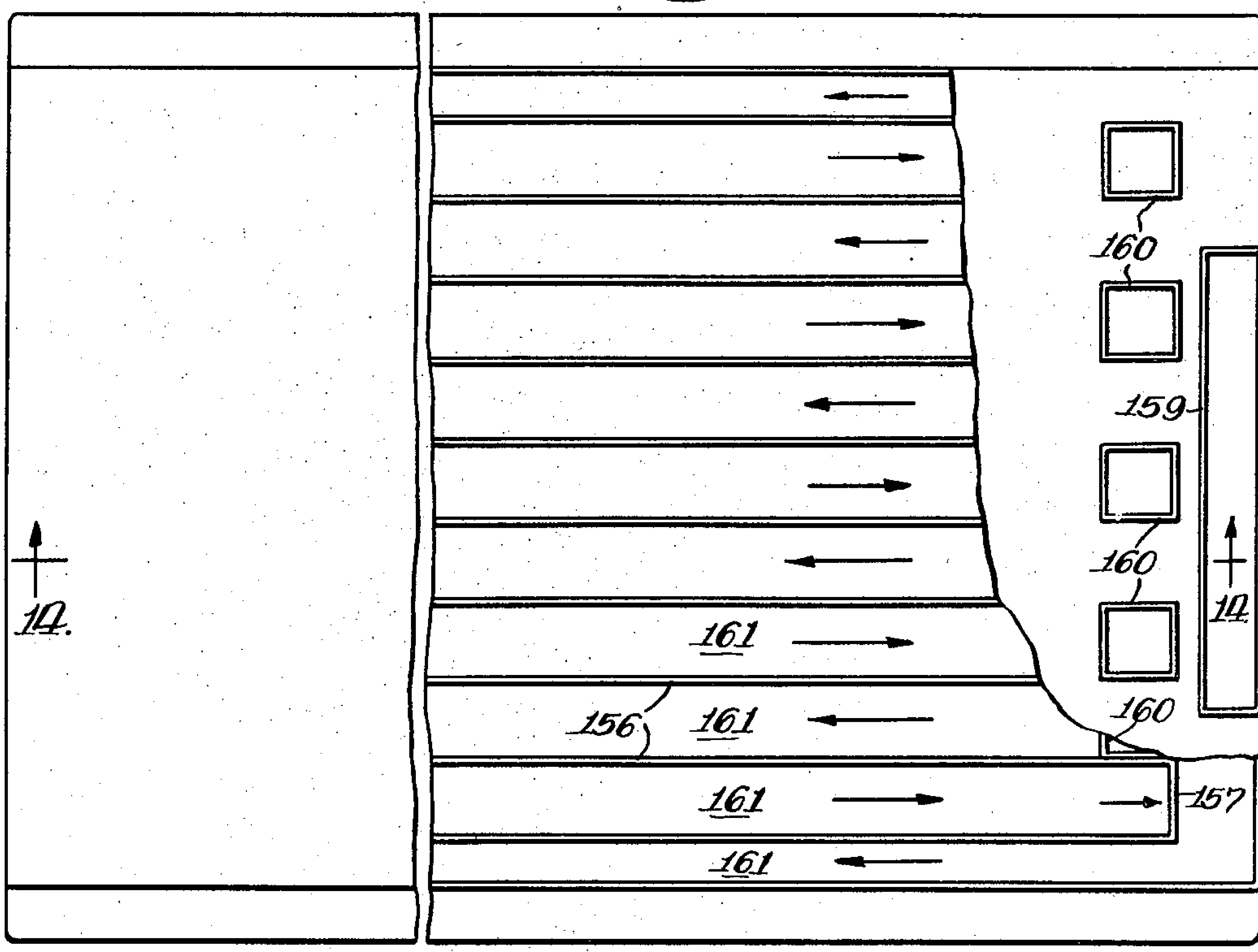

Fig. 14.

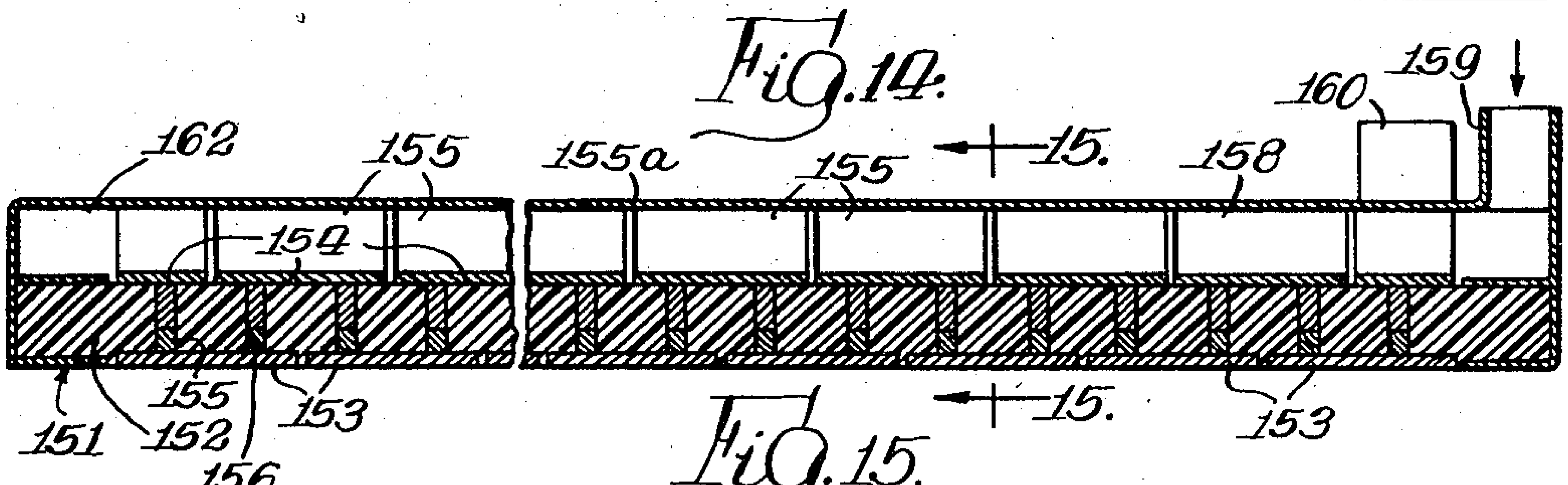

Fig. 15.

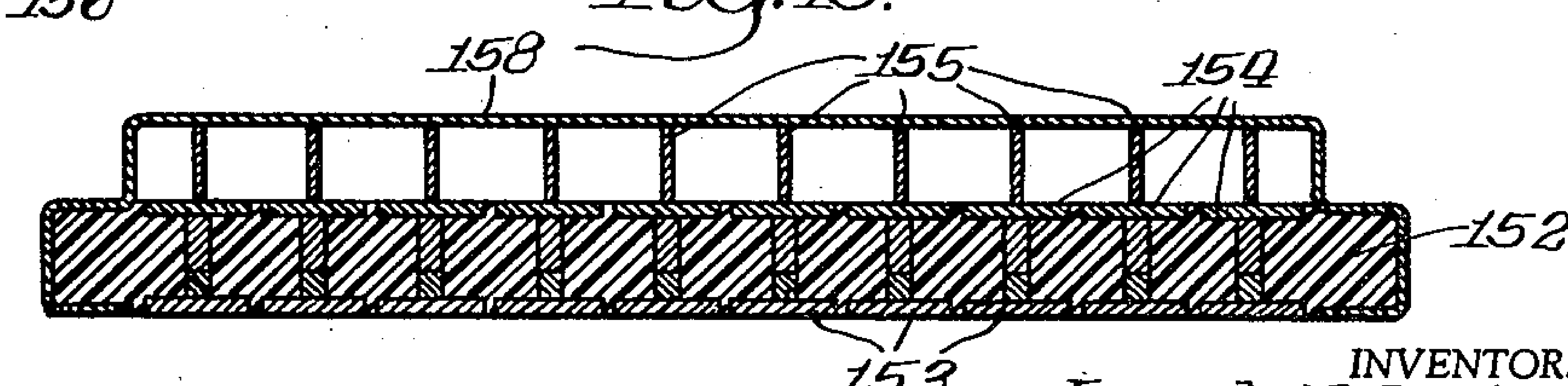

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Fig. 16.

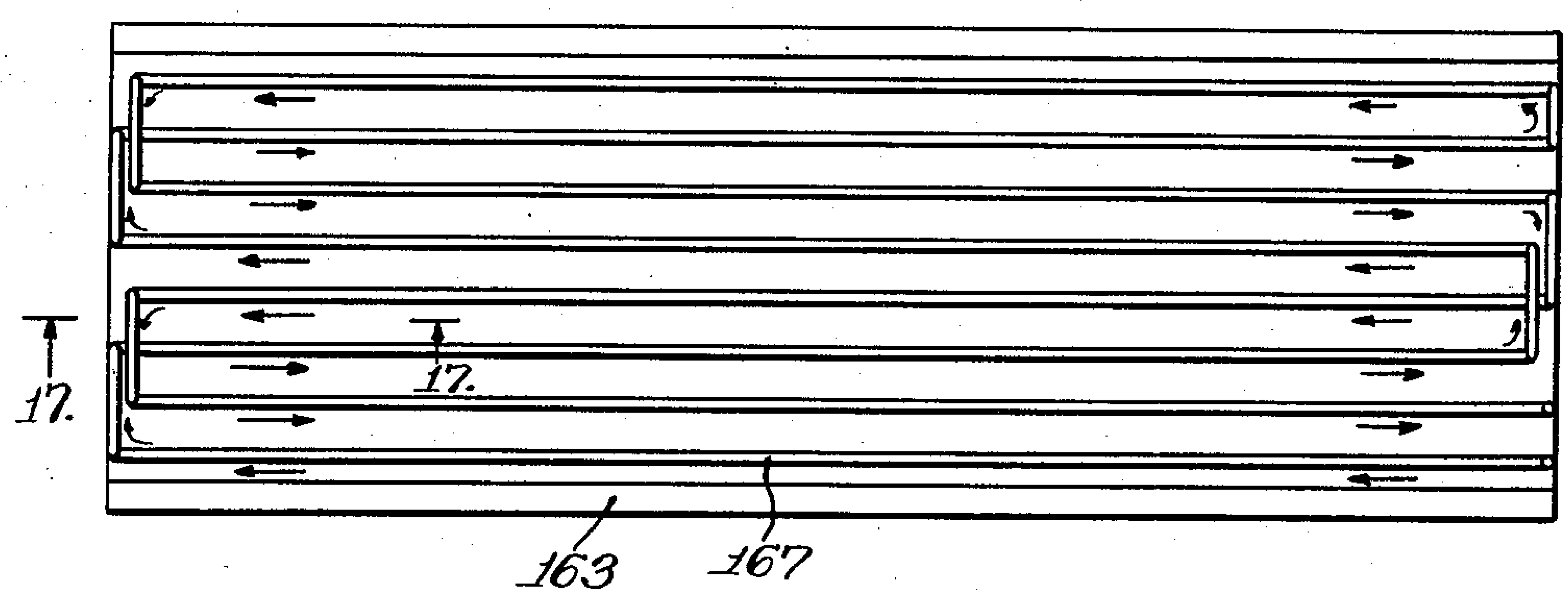

Fig. 17.

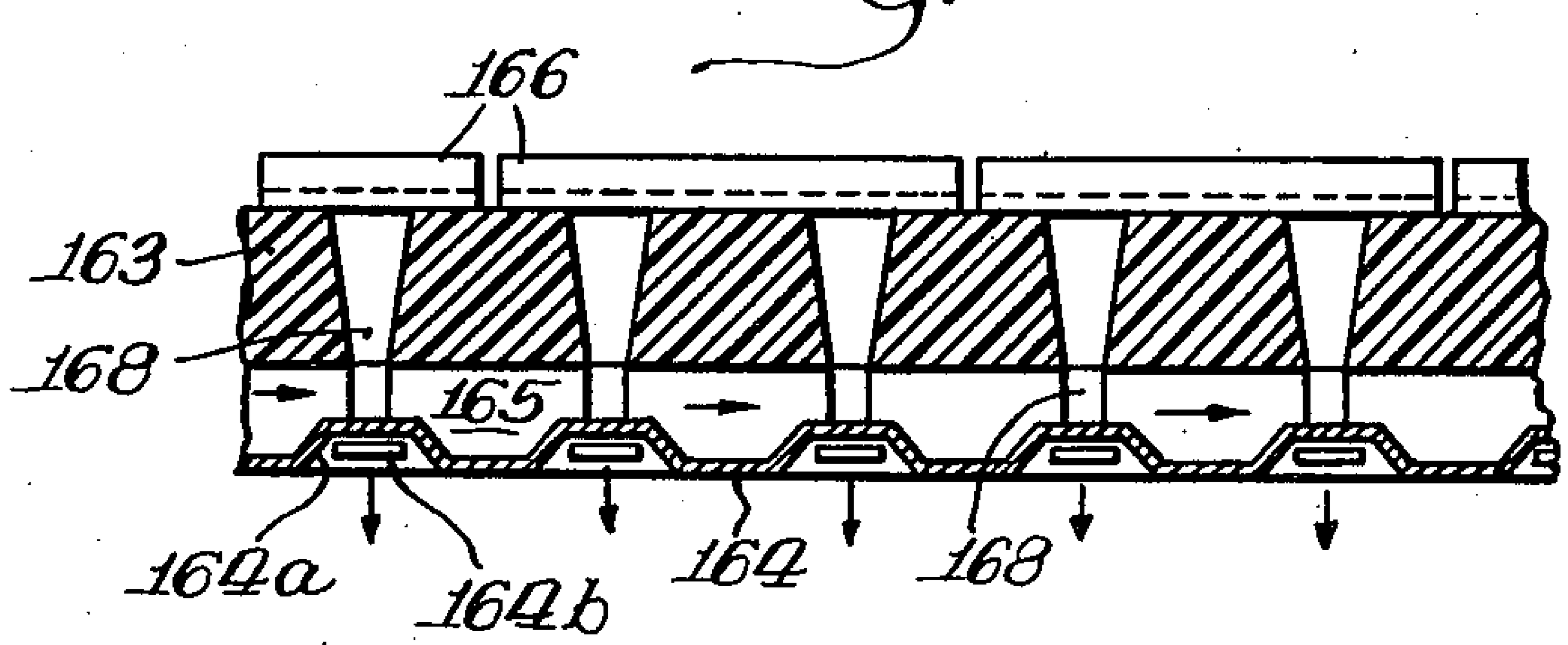

Fig. 18.

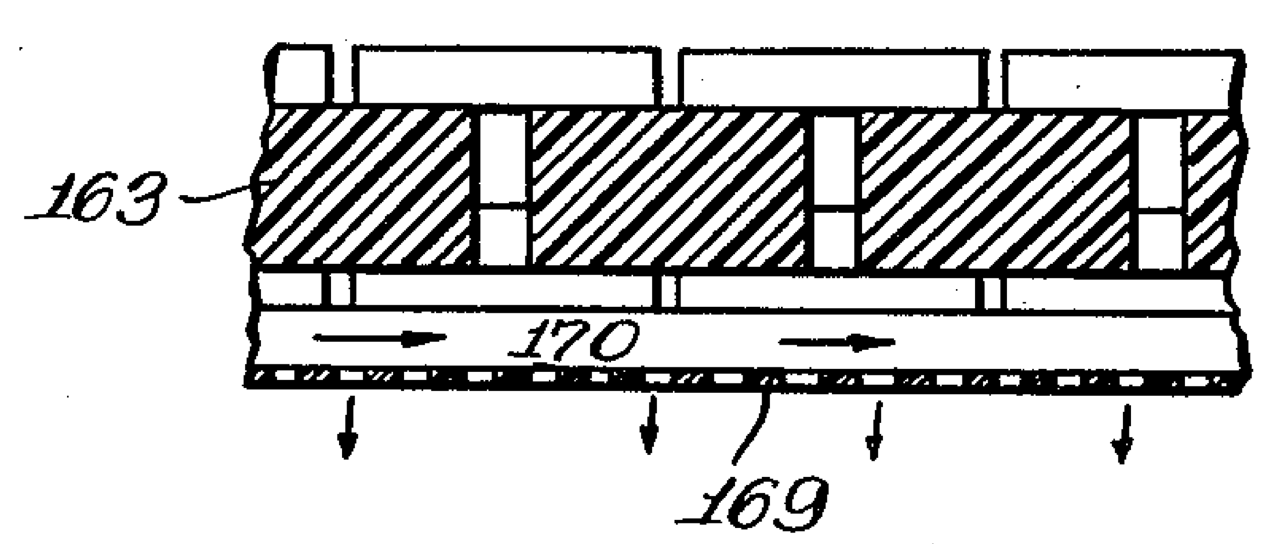

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Fig. 19.

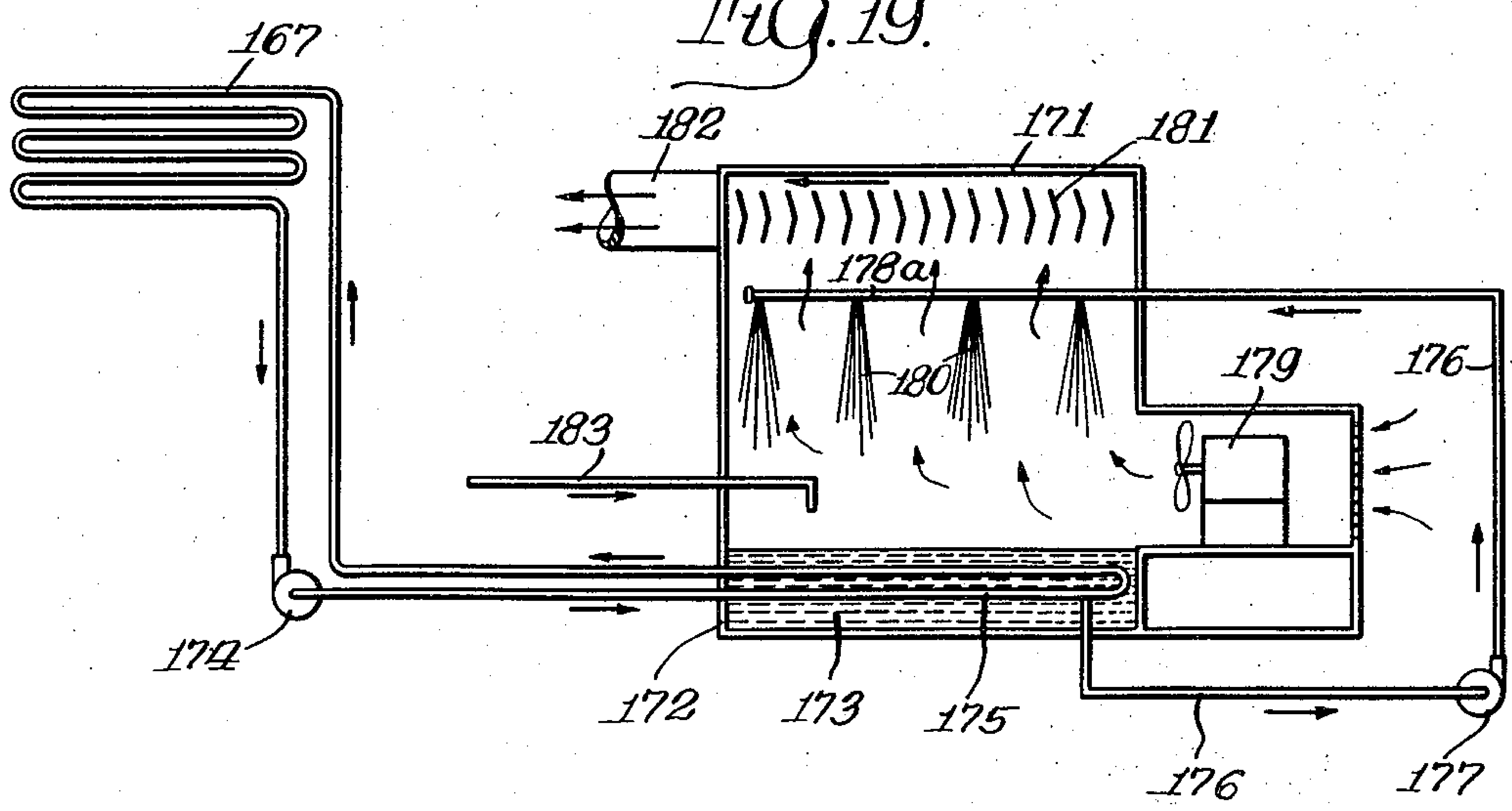
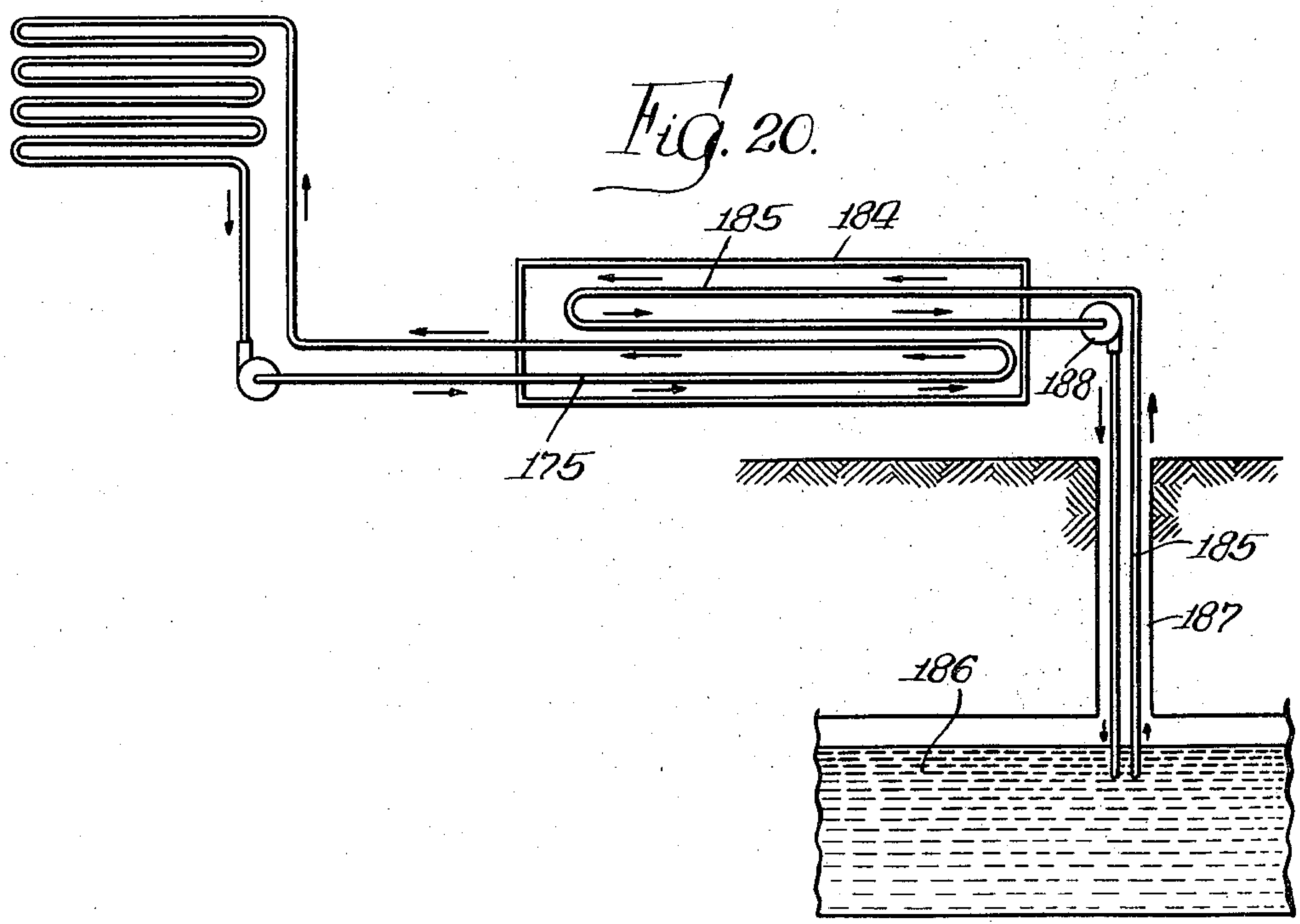


Fig. 20.



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THERMOELECTRIC AIR CONDITIONING APPARATUS

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Filed June 2, 1958, Ser. No. 739,045

29 Claims. (Cl. 62—3)

This invention relates to refrigerating apparatus and particularly to thermoelectric refrigerating apparatus that can be used for cooling and for heating a desired space such as a room.

The invention here is primarily concerned with air conditioning a space. It employs a pair of thermocouple structures and associated parts with both structures having a pair of spaced sets of thermocouple junctions, one of which is cold and the other of which is hot when thermoelectric current (normally a direct current) is passed through these sets in one direction, but with these thermal conditions being reversed when the current is passed in the opposite direction. Means are provided for exposing one set, a cold set when cooling air conditioning is desired, of the junctions of the first thermocouple structure in radiant heat transfer relationship with the space being conditioned. This radiant cooling serves to absorb sensible heat from the space. When the direction of the electric current flow is reversed, the hot set of junctions will, of course, cause radiant heating in the space. Means are also provided for thermally contacting air from the space in heat exchange relationship with one set, the cold set when cooling is desired, of junctions of the second thermocouple structure, in order to remove latent heat and humidity from the room. In addition, the room air during this circulation is preferably filtered.

One of the features of this invention, therefore, is to provide such an improved refrigerating apparatus employing banks of thermocouples with one bank of couples being in radiant heat transfer relationship to the space and a second bank being arranged to permit the circulation of the air thereover in combination with auxiliary apparatus for filtering and removing moisture from the air in the space. Thus, when cooling is desired, the first bank will provide radiant cooling while the second bank and its associated structure will cool, remove latent heat and and remove moisture to dehumidify the air.

Another feature of the invention is to provide improved thermoelectric radiant panels for heating or cooling.

A further feature of the invention is to provide an improved apparatus including a thermoelectric structure for removing latent heat and moisture from air circulated therethrough.

Other features and advantages of the invention will be apparent from the following description of certain embodiments thereof.

Fig. 1 is a diagrammatic view of an air conditioning system for a room.

Fig. 2 is a view similar to Fig. 1 showing a second embodiment of an air conditioning system.

Fig. 3 is a semi-diagrammatic view of an apparatus for filtering, cooling and dehumidifying air.

Fig. 4 is a semi-diagrammatic view of a second embodiment of a dehumidifying and cooling apparatus.

Fig. 5 is a similar view showing a third embodiment of such an apparatus.

Fig. 6 is a similar view showing a fourth embodiment of such an apparatus.

Fig. 7 is a plan view partially broken away for clarity of illustration of a radiant panel usable for cooling or for heating, as desired.

Fig. 8 is a side elevational view of the panel.

Fig. 9 is a bottom view of the panel partially broken away for clarity of illustration.

Fig. 10 is a fragmentary sectional view taken substantially along line **10—10** of Fig. 7.

Fig. 11 is a fragmentary plan view taken substantially along line **11—11** of Fig. 10.

Fig. 12 is a fragmentary sectional view taken substantially along line **12—12** of Fig. 7 but omitting detailed views of the junctions.

Fig. 13 is a plan view partially broken away for clarity of illustration of a second embodiment of a panel.

Fig. 14 is a sectional view taken substantially along line **14—14** of Fig. 13.

Fig. 15 is a sectional view taken substantially along line **15—15** of Fig. 14.

Fig. 16 is a plan view of a third embodiment of a panel showing only the water cooling lines or piping in detail.

Fig. 17 is a sectional view taken substantially along line **17—17** of Fig. 16 but omitting the water lines.

Fig. 18 is a view similar to Fig. 17 but showing a fourth embodiment of a panel.

Fig. 19 is a diagrammatic view of one embodiment of a water cooling system for the hot junctions of the panels of Figs. 16 to 18, inclusive.

Fig. 20 is a view similar to Fig. 19 but showing a second embodiment of such a water cooling system.

As pointed out above, the air conditioning apparatus here employs a plurality of sets of thermocouples to produce a cooling or a heating effect, dependent upon the direction of flow of the thermoelectric current. Typical thermoelectric structures operating on the well known Peltier effect are shown and described in the form of panels in the co-pending application of M. K. Baer, Jr. and C. R. Lopp, entitled "Refrigerating Apparatus," Serial No. 735,804, filed May 16, 1958. As is pointed out there, each thermocouple structure employs a plurality of pairs of dissimilar thermoelectric elements connected in electrical series by a connection including junctions with all of the cold junctions being located in one set and all of the hot junctions located in another set with the two sets being spaced apart. When the thermoelectric current flows in one direction one set of junctions operate as cold junctions. When the direction of this current is reversed, the former cold junctions operate as hot junctions while the former hot junctions operate as cold junctions. These are well known effects widely described in the published literature.

Fig. 1 illustrates diagrammatically a system for cooling or heating the air in a room **21**. The construction and operation of the air conditioning system will be described for cooling the room. It is of course understood that it is only necessary to reverse the direction of thermoelectric current in order to produce a heating effect.

The ceiling of the room is provided with radiant panels **22** of which typical embodiments will be described in detail hereinafter. The interior **23** of the panels is hollow in order to provide air flow passages. Means are provided at the top **22a** of the panel to permit the air from the interior passage **23** to pass into the attic **24** or other space adjacent to and preferably above the room **21**. Also located above the room **21** is a unit **25** for dehumidifying, cooling and filtering air drawn from the room and then passed back into the room in a continuous circulation. Typical embodiments of such a unit will be described hereinafter.

At the same time the blower 65 is drawing air through the other air flow path 49. Here the air flows in the inlet 63, through the filter 62a and over and around the fins 60 for cooling the hot junctions 58. The thusly heated air then passes down through the portion of the desiccant bed 45 in the air path 49 where the heated air removes moisture from the desiccant in a reactivation step. As the motor 46 rotates in bed 45 the one side of the bed removes moisture from the circulated room air while the other side of the bed is being reactivated by the heated outside air that has been passed over the hot junction fins 60.

Although the air in the path 49 heated by the hot junctions 58 and fins 60 will ordinarily be sufficiently hot to reactivate the desiccant bed 45, additional heat may be supplied to this air if desired as by means of an auxiliary electric heating element (not shown).

In the embodiment shown in Fig. 4 a thermoelectric structure 66 is provided similar to the structure 51 of the embodiment of Fig. 3. The structure is provided with cold junctions 67 having outwardly extending fins 68. The other side of the thermoelectric structure is similarly provided with hot junctions 69 and attached fins 70. The entire structure is surrounded by a housing 71 to provide a pair of air paths 72 and 73 separated from each other by the thermoelectric structure 66. The sides of the structure 66, including the junctions 67 and 69 and the fins 68 and 70, are provided with an adhered coating of desiccant 74. This desiccant, like that in the bed 45 of the Fig. 3 embodiment, may be silica gel, activated alumina or any of a large number of well known desiccants. In this embodiment the desiccant is adhered to the thermoelectric structure parts so as to be closely bound thereto in the well known manner.

In operation air is drawn from the room through a conduit 75 and filter 76 by means of a blower 77. This air is then forced through one side of a rotatable four-way valve 78 into the bottom of the air path portion 72 of the housing 71. As this humid air from the room passes up the path 72 in contact with the adhered desiccant 74 the desiccant absorbs moisture from the air. The air is simultaneously cooled by the cold plates so that the latent heat is absorbed at no increase in temperature. The room air then passes out the top of the air passage 72 through a conduit 79 by way of another four-way valve 80 and is conveyed back into the room.

During the above described operation outside air is drawn in through an upper conduit 81 and filter 82 and is directed by means of the upper four-way valve 80 into the top of the air path portion 73. Here it passes downwardly in contact with the desiccant coating on the hot junctions 69 and associated fins 70.

After the desiccant 74 in the air path 72 has become substantially saturated with moisture, the direction of direct current flow through the thermocouple structure 66 is reversed so that the cold junctions 67 become hot junctions and the hot junctions 69 become cold junctions. The four-way valves 78 and 80 are then reversed so that room air in the inlet conduit 75 is directed upwardly through the path 73 and out the exit conduit 79. Similarly, outside cooling air is directed from the inlet conduit 81 through the air path 72 to remove moisture from the desiccant 74 in this path and is then directed back to the outside through the exit conduit 83.

In the embodiment of Fig. 5 a pair of desiccant beds 85 and 86 are provided so that one bed is being employed for absorbing moisture while the other bed is being reactivated. In this embodiment humid air from the room is led through a conduit 87 and a blower 88 by way of a filter 89 through one side of a four-way valve 90 into a conduit 91 leading to the bottom of the first desiccant bed 85. From the bed 85 the filtered and dried air is passed through a conduit 92 and one side of a second four-way valve 93 into a conduit 94 leading to one side of a casing 95. This casing 95 is divided centrally by means of a thermoelectric structure 96 similar to the previously described structure 51 in the embodiment in Fig. 3. The air passes downwardly in a path 97 on one side of the structure 96 and contacts cold junctions 98 and associated fins 99. From the bottom of the casing 95 the filtered, dried and cooled air passes through a conduit 100 back into the room.

At the same time air is drawn through an inlet conduit 101 from the outside and passed through a filter 102 into the bottom of the air path 103 in the casing 95 on the other side of the thermoelectric structure 96. As the air here passes upwardly it is heated by contact with the hot junctions 104 and associated fins 105. The heated air then passes upwardly through conduit 106 and four-way valve 93 to conduit 107 where it is directed into the top of the second desiccant bed 86. The air which has thus been heated by the hot junctions passes down through the bed 86 to remove moisture therefrom and reactivate this bed. From the bottom of the bed 86 the heated moisture-laden air passes through conduit 108, four-way valve 90 and blower 109 back into the atmosphere.

When the bed 85 becomes substantially saturated with moisture and the bed 86 has been thusly reactivated, the positions of the valves 90 and 93 are reversed so that the room air from blower 88 is directed into conduit 108 and up through reactivated bed 86. From there the dried air passes through conduits 107 and 94 down into the cold air path 97 and out the conduit 100 into the room. At the same time air from the hot air path 103 is directed through conduits 106 and 92 downwardly through bed 85 and back to the outside by way of conduit 91 and blower 109.

In the embodiment shown in Fig. 6, three thermoelectric structures 110 are provided, each similar to the thermoelectric structure 51 previously described in detail and all connected in electrical series by connecting leads 110a. A pair of hot air paths 111 and 112 and a pair of cold air paths 113 and 114 are provided. The arrangement of junctions and associated fins in these paths is essentially the same as that described in the embodiment shown in Fig. 3 in connection with the thermoelectric structure 51.

Moist room air is drawn through the conduit 115 and filter 116, through conduit 117 and branches 118 into the top of cold air chambers 113 and 114. The room air passes downwardly through the cold air paths, being cooled by the cold junctions and associated fins and then passes through a bottom conduit 119 and a blower 120 back into the room by way of a conduit 121. A by-pass conduit 122 is provided extending between the upper conduit 117 and the lower conduit 119 to permit blending room air by means of a mixer 123 of conventional design with chilled room air in the conduit 119 before blowing the mixture back into the room. This mixing is optional and may be done as desired in the proportions desired.

During the operation of the apparatus outside room air is drawn through a conduit 124, filter 125 and blower 126 into lower conduit 127. From this conduit the air passes upwardly by way of branches 128 into the bottom of the hot air paths 111 and 112. This air serves to cool the hot junctions and fins in these paths and passes outwardly through conduit 129 back into the atmosphere. As can be seen from Fig. 6, the air in the hot air paths 111 and 112 passes countercurrently with the air in the cold air paths 113 and 114. This serves to keep the temperature differences across the thermoelectric structure 110 approximately constant at all points, thereby assuring substantially uniform performance of each thermoelement in each thermoelectric structure.

As the air from the room passes down through the cold air paths 113 and 114, moisture condenses on the cold junctions and cold fins in these paths and drips down to collect in moisture traps 130. This moisture is drawn off through lines 131 and 132 to a pump 133. The moisture from the pump then flows upwardly through line 134 and is sprayed into the top of each hot air path 111 and 112 as indicated at 135. Any of this moisture that is not vaporized in the hot air paths 111 and 112 is collected in bottom moisture traps 136 in line 127 immediately beneath the conduit branches 128 for reintroduction into the line 132. If amounts of water are required in addition to the condensate, these may be supplied through a water inlet line 137 leading to the line 132.

If desired, the embodiment of Fig. 6 may also be used for heating and humidifying the air. The room air is passed through the hot paths 111 and 112 and water from line 137 as sprayed as indicated at 135 in order to provide moisture. The heated moisturized air could then be conveyed back into the room.

Figs. 7 to 20, inclusive, illustrate various embodiments of thermoelectric panels for radiant heating and cooling as indicated at 22 in the air conditioning system embodiments of Figs. 1 and 2.

In the panel embodiment of Figs. 7 to 12, inclusive, the panel includes spaced sections of insulating material 138 and 139 which may be foamed-in-place insulation of the type previously described. The two essentially rectangular sections of insulating material are spaced from each other to provide an air chamber 145. Located within the bottom section of insulating material 138 are a plurality of pairs of dissimilar thermoelectric elements 140 and 141 as previously described. These elements are connected in electrical series by means of surface junction plates 142 on the bottom surface of the insulating material 138 and junction bar 143 in the section 139. Attached to these bars are metal stems 144 that extend through the air space 145 and are in electrical contact with the elements 140 and 141. Thus, with this arrangement, the junction plates 142, thermoelectric elements 140 and 141, junction bars 143 and stems 144 are all connected in electrical series as previously described.

The junction bars 143 are of essentially dumbbell shape with a pair of spaced cylindrical members 143*a* spaced from each other connected by means of a web 143*b*. The bar 143 is sufficiently thick that it extends through the insulation 139 so that the bottom surface of each bar is exposed to the air chamber 145 between the insulation materials 138 and 139. Each cylindrical member 143*a* of a bar 143 is provided with a plurality of circularly arranged openings 146 extending from the air chamber 145 through the bar. These are for the passage of air from the chamber 145 through the bar into air space 149 (Fig. 12).

The top portion of the thermoelectric panel of this embodiment is enclosed by means of a hood 147. Passing down through this hood is an air inlet conduit 148 that extends into the air chamber 145. The upper portion of the insulating material 139 is spaced from the hood 147 in order to provide the air space 149. Extending from this air space are a pair of conduits 150.

In operation, the panel of this embodiment is arranged with the junction plates 142 exposed. Thus, in the embodiments of Figs. 1 and 2, the thermoelectric panel would be in the ceiling with the plates 142 exposed for radiant heat transfer to the room. With the current flowing through the thermoelectric structure in one direction, as has been previously described, the junction plates 142 would operate as cold plates to cool the room by radiant heat transfer. Simultaneously, cooling air would be passed through the conduit 148 such as from either the conduit 31 or 33 into the air chamber 145. The air from this chamber 145 then flows out through the small holes 146 to cool the hot junction bars 143 and from there passes into the air space 149 and through the conduit 150 into the attic 24 and from there to the outside air. When it is desired to heat the air of the room the electric current flow to the structure is reversed so that the junction plates 142 operate as hot plates to heat the air by radiant heat transfer.

In the embodiment shown in Figs. 13 to 15, the thermoelectric panel 151 comprises a flat block of insulating material 152 which may be of the nature previously described having one set of junctions 153 on one side and a second set of junctions 154 on the other side. These junctions 153 and 154 are arranged in electrical series with dissimilar thermoelectric elements 155 and 156 in the manner previously described so that one set of junctions will operate as cold junctions while the other set operates as hot junctions when the thermoelectric current passes in one direction. Upon reversal of this direction the thermal nature of the junctions will be reversed.

The junctions 154 have attached thereto upwardly extending thin metal fins 155 arranged in parallel rows 156 as illustrated in Fig. 13. In this figure the individual fins are not distinguished in order to show the continuous nature of the arrangement, but they are distinguished in Fig. 14. The adjacent edges of the fins in each row are sealed as by rubber sealing means 155*a*. The alternate ends of the rows 156 are provided with cross-partitions 157. The rows 156 are provided with a sealing cover 158. Extending upwardly from this cover is an elongated inlet 159 for inlet heat transfer air. Also extending outwardly from the cover 158 are a plurality of outlet conduits 160. One outlet is arranged opposite the end of each alternate air channel 161. These air channels are formed by the top junctions 154, aligned fins 155, partitions 157 and cover 158. Each pair of adjacent channels 161 are joined at the ends by cross-chambers 162.

With this arrangement, air flows in through the air conduit 159 to one end of the space beneath the cover 158 which serves as a manifold. From here the air flows down a first air chamber 161 to the opposite end where it flows through a cross-chamber 162 into the next air chamber 161. The air flows forwardly in this chamber 161 and then upwardly through an exit conduit 160. Similarly, the air flows from the intake conduit 159 to the next air flow chamber 161, through the corresponding cross-chamber 162 and back through the next flow chamber 161 and out the next exit 160. This arrangement provides heat transfer air for cooling the junctions 154 and fins 155 when the junctions 153 are operating as cold junctions and the junctions 154 are operating as hot junctions. When the current is reversed so that the junctions 154 are the cold junctions as when heating a room by radiant heat, the air will then serve to provide heat to the cold junctions 154.

In the embodiment shown in Figs. 16 and 17 the insulation material 163 is of the nature previously described. Here, one set of junctions 164 is spaced from the insulation material 163 in order to provide an air chamber 165. The other set of junctions 166 are on the opposite surface of the insulation material 163 and are curved in cross-section as a section of a cylindrical surface to support and make intimate contact with water pipes 167. These pipes are shown in Fig. 16 but are not shown in Fig. 17. The junctions 164 are recessed as indicated at 164*a* in the vicinity of the electrical connectors 168 of the thermoelectric structure. These depressed portions are provided with openings 164*b*. With this arrangement air blown through the air chamber 165 will be cooled or heated by junctions 164 depending upon the direction of the current flow through the structure and will then pass into the room. In the usual manner, where the junctions 164 are cold junctions, the air will be cooled. At the same time the junctions 164 will operate as radiant heat transfer junctions to cool or heat the air in the room as desired.

When the junctions 166 are hot junctions, they are cooled by water flowing through the pipes 167 in the manner illustrated in Fig. 16. When the air in the room is being heated, as previously described, this water will supply heat to the cold junctions 166.

The embodiment shown in Fig. 18 is similar to that shown in Figs. 16 and 17. Here, however, a perforated panel 169 is provided on the room side of the air chamber 170 so that air may pass through the perforated panel into the room.

Figure 19 illustrates a source of water for cooling the hot junctions of the panels, Figures 16, 17 and 18, when these panels are used for radiant cooling. Here, there is provided a cooling tower 171 provided with a sump 172 adapted to contain a body of water 173. Water is circulated by means of a pump 174 through the pipes 167 and through a length of pipe 175 immersed in the water 173 through a continuous path. In order to dissipate the heat absorbed by the body of water 173 this water is circulated by means of a pipe 176 and a pump 177 into a series of spray nozzles 178 above the water 173 in the cooling tower 171. In order to further aid the cooling effect, a motor driven fan 179 blows air through the sprays 180 of water with the air flowing through a series of baffles 181 and then out an exhaust 182 from the tower 171. There will, of course, be a certain amount of evaporation of water in this system so that means including a pipe 183 are provided for supplying makeup water.

The second embodiment of such a cooling water system is shown in Figure 20. The system here is essentially the same as that shown in Figure 19 except that here the heat exchange pipe 175 is located in a heat exchanger 184 where the pipe is in heat transfer relationship with a piping system including pipes 185 through which water 186 is circulated from a deep well 187 or the like by means of a pump 188.

As has been pointed out herein, the air conditioning system of this invention employs radiant panels which may be used as cooling panels for absorbing sensible heat or may be used as radiant heating panels depending upon the direction of current flow through these panels. The system also uses thermoelectric structures for cooling and dehumidifying the air to remove latent heat and also includes means for filtering and removing moisture. In certain embodiments this moisture is the cold portion of the thermoelectric structure. Such a system has been found easier to control to give the desired temperature, humidity and other comfort factors and may also be easily converted for heating during the cool seasons of the year. The system includes thermoelectric radiant panels of improved construction and also includes the improved units for filtering and removing latent heat and moisture.

Having described our invention as related to the embodiments set out herein, it is our intention that the invention be not limited by any of the details of description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

We claim:

1. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first structure in radiant heat transfer relationship with said space; and means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said second structure.

2. The apparatus of claim 1 wherein said one set of the first structure is located at the top of said space and facing the space.

3. The apparatus of claim 1 wherein means are provided for circulating air from outside said space in thermal conducting relationship with said other sets.

4. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; moisture absorbing apparatus; means exposing said one set of junctions of said first structure in radiant heat transfer relationship with said space; and means for circulating air from said space in moisture absorbing contact with said moisture absorbing apparatus and in thermal contact with the one set of junctions of said second structure.

5. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; moisture absorbing apparatus; means exposing said one set of junctions of said first structure in radiant heat transfer relationship with said space; means for circulating air from said space in moisture absorbing contact with said moisture absorbing apparatus and in thermal contact with the one set of junctions of said second structure; and apparatus utilizing the heat from at least one of said sets of hot junctions for regenerating and driving moisture from said moisture absorbing apparatus.

6. The air conditioning apparatus of claim 5 wherein said moisture absorbing apparatus is in at least two portions, with means for alternately regenerating one portion while the other portion is being utilized for said moisture absorbing.

7. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first structure in radiant heat transfer relationship with said space; means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said second structure; means for collecting the condensate from the cold junctions of the second structure; and means for transferring the condensate to the set of hot junctions for cooling the same.

8. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including substantially flat, substantially coplanar, heat transfer members thermally exposed on one surface of the panel; a second thermocouple structure having a pair of spaced

sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said panel in radiant heat transfer relationship with said space; and means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said structure.

9. The apparatus of claim 8 wherein means are provided forming a fluid passage in said panel for the cooling and ventilating of said hot junctions.

10. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including substantially flat, substantially coplanar, heat transfer members thermally exposed on one surface of the panel, the other set of junctions being spaced from the one set to provide an internal passage for heat transfer fluid; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first panel in radiant heat transfer relationship with said space; and means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said structure.

11. The apparatus of claim 10 wherein at least some of said second set of junctions of the panel contain openings therethrough for the passage of said fluid.

12. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including substantially flat, substantially coplanar, heat transfer members thermally exposed on one surface of the panel, the other set of junctions being spaced from the one set to provide a hollow space for heat transfer fluid, the other set of junctions containing a plurality of openings communicating with said hollow space for the passage of said fluid; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first panel in radiant heat transfer relationship with said space; and means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said second structure.

13. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including substantially flat, substantially coplanar, heat transfer members exposed on one surface of the panel; a housing surrounding said other set of junctions for heat transfer fluid having a fluid inlet and outlet; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first panel in radiant heat transfer relationship with said space; and means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said second structure.

14. The apparatus of claim 13 wherein said second set of junctions of the panel are provided with heat conducting fins arranged and aligned to provide an elongated fluid path over said second set of junctions of the panel.

15. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including substantially flat, substantially coplanar, heat transfer members thermally exposed on one surface of the panel; a panel support for said junctions spaced from said one set of junctions of the panel to provide an air chamber therearound communicating with said space; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first panel in radiant heat transfer relationship with said space; and means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said second structure.

16. Heat transfer apparatus, comprising: a thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including substantially flat, substantially coplanar, heat transfer members thermally exposed on one surface of the panel, the other set of junctions being spaced from the one set to provide a hollow space for heat transfer fluid, the other set of junctions having a plurality of openings associated therewith communicating with said hollow space for the passage of said fluid.

17. Heat transfer apparatus, comprising: a thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including substantially flat, substantially coplanar, heat transfer members thermally exposed on one surface of the panel; and a support for said one set of junctions maintaining said one set spaced from said other set of junctions of the panel to provide an air chamber therearound.

18. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first structure in radiant heat transfer relationship with said space; means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said second structure; and means for thermally contacting heat exchange fluid with said other set of junctions of at least one of said first and second thermocouple structures.

19. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including heat transfer members thermally exposed on one surface of the panel; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first panel in radiant heat transfer relationship with said space; and means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said second structure.

20. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including heat transfer members thermally exposed on one surface of the panel; means providing a fluid passage in said panel for heat transfer fluid; a second thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; means exposing said one set of junctions of said first panel in radiant heat transfer relationship with said space; and means for thermally contacting air from said space in heat transfer relationship with said one set of junctions of said second structure.

21. The apparatus of claim 20 wherein at least some of said other set of junctions of the panel contain openings therethrough communicating with said fluid passage.

22. Air conditioning apparatus for conditioning the air in a space, comprising: a thermocouple structure having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction; moisture absorbing apparatus having first and second portions; means for circulating air from said space in moisture absorbing contact with said first portion and in thermal contact with said one set of junctions; means for circulating drying fluid in moisture removing contact with said second portion and in thermal contact with said other set of junctions; and means for reversing said first and second portions when said first portion is relatively moist and said second portion is relatively dry.

23. The apparatus of claim 22 wherein said first portion is normally upstream from said one set and the second portion is normally downstream from said other set.

24. The apparatus of claim 22 wherein said first portion is in direct contact with said one set and the second portion is in direct contact with said other set.

25. Heat transfer apparatus, comprising: a thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including heat transfer members thermally exposed on one surface of the panel; and a housing surrounding said other set of junctions for heat transfer fluid having a fluid inlet and outlet, said other set of junctions being provided with heat conducting members in thermal contact therewith at least some of which are aligned to provide an elongated fluid path for heat transfer fluid.

26. The apparatus of claim 25 wherein said heat conducting members are flat with a plurality thereof arranged in rows providing a plurality of said paths.

27. Air conditioning apparatus for conditioning the air in a space, comprising: a first thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including heat transfer members thermally exposed on one surface of the panel; and an outer surface member including said heat transfer members spaced from said other set of junctions to provide a chamber, the surface member being provided with a plurality of openings communicating with said chamber and with the air in said space.

28. Heat transfer apparatus, comprising: a thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including substantially flat, substantially coplanar, heat transfer members exposed on one surface of the panel; and a housing surrounding said other set of junctions for heat transfer fluid having a fluid inlet and outlet, said other set of junctions of the panel being provided with heat conducting fins at least some of which are aligned to provide an elongated fluid path over said other set of junctions of the panel.

29. Heat transfer apparatus, comprising: a thermocouple panel having a pair of spaced sets of junctions one of which is cold and the other of which is hot when direct current is passed through said sets in one direction, these thermal conditions being reversed when said current is passed in the opposite direction, the one set of junctions including heat transfer members thermally exposed on one surface of the panel; and means providing a fluid passage in said panel for heat transfer fluid, at least some of said other set of junctions of the panel contain openings through said junctions communicating with said fluid passage.

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APPARATUS FOR ULTRASONIC MATERIALS TESTING

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Fig. 1.

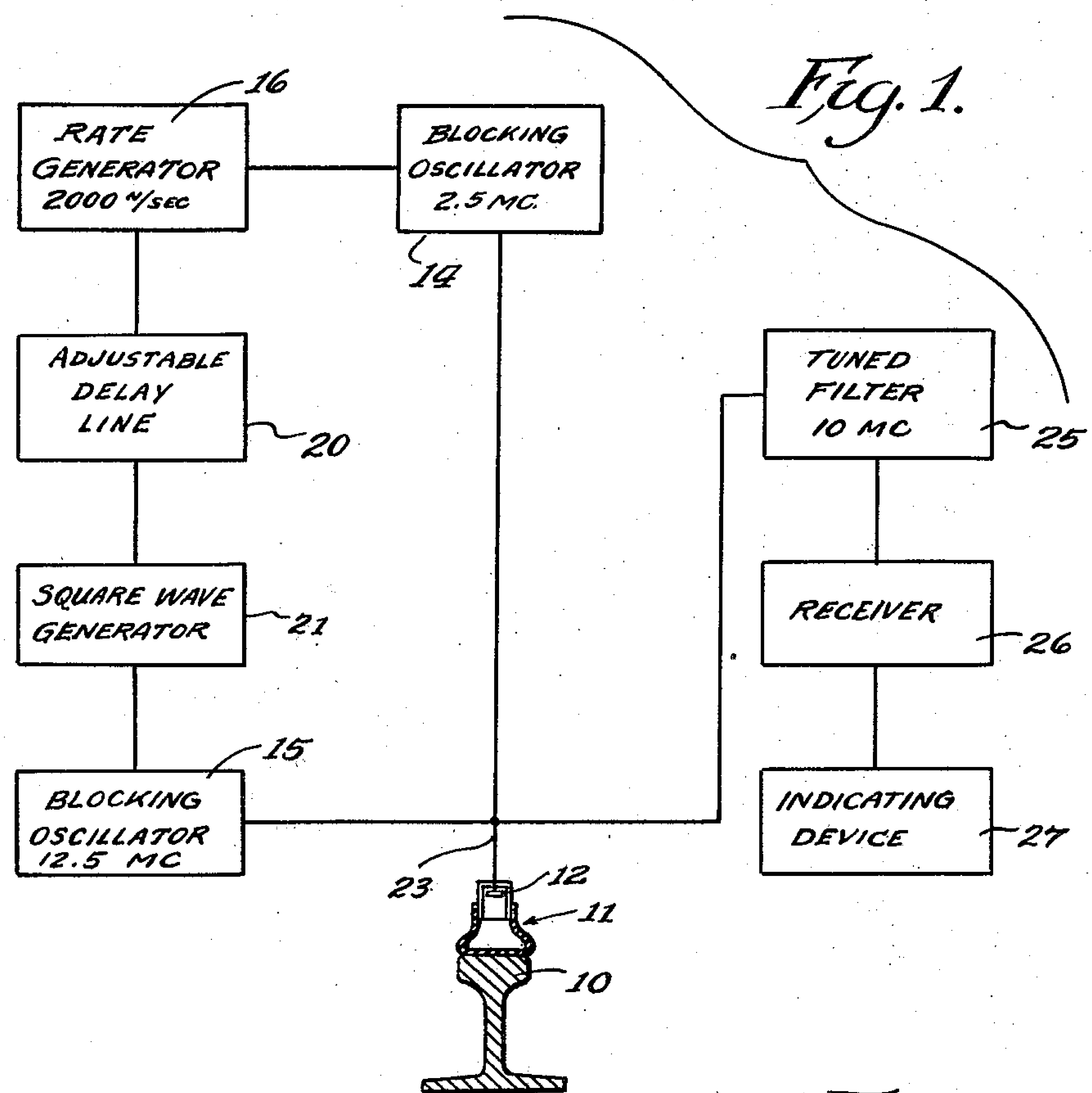
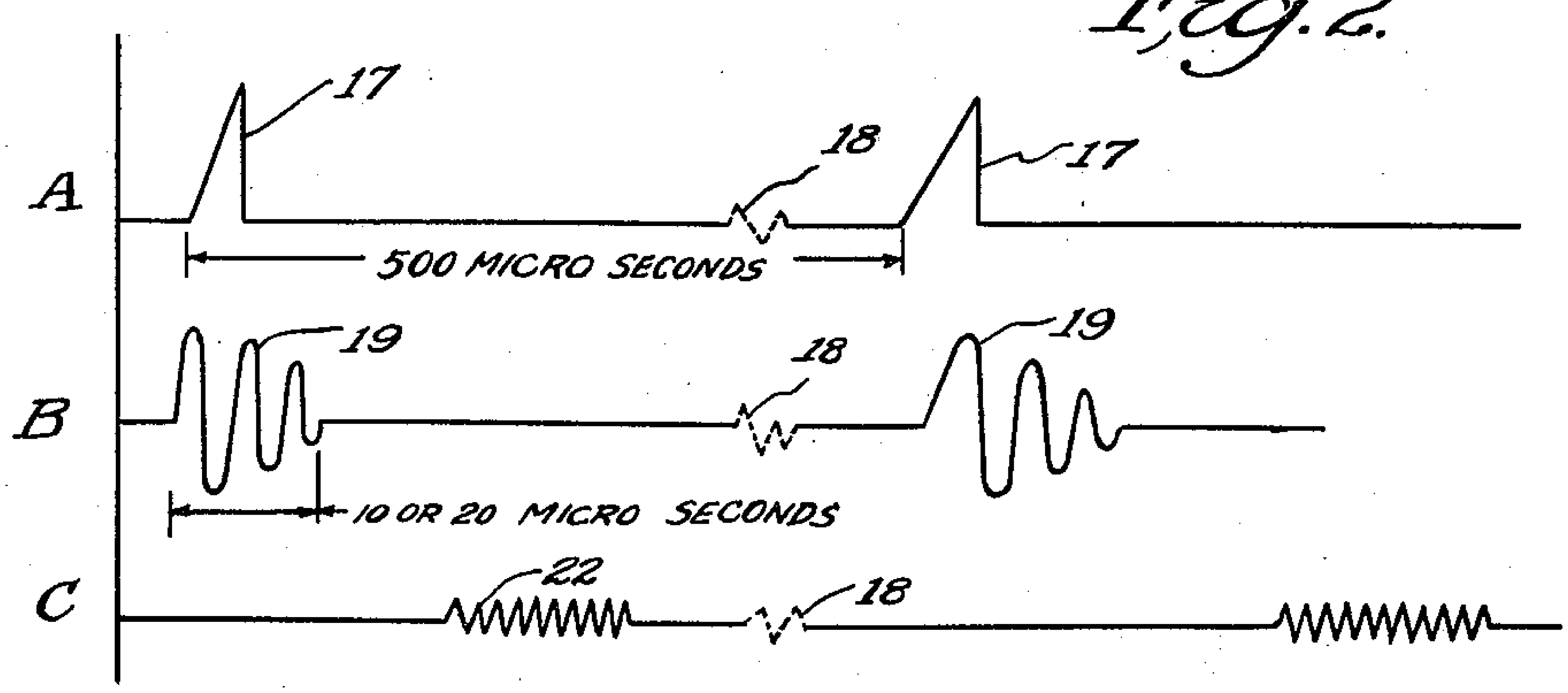


Fig. 2.



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