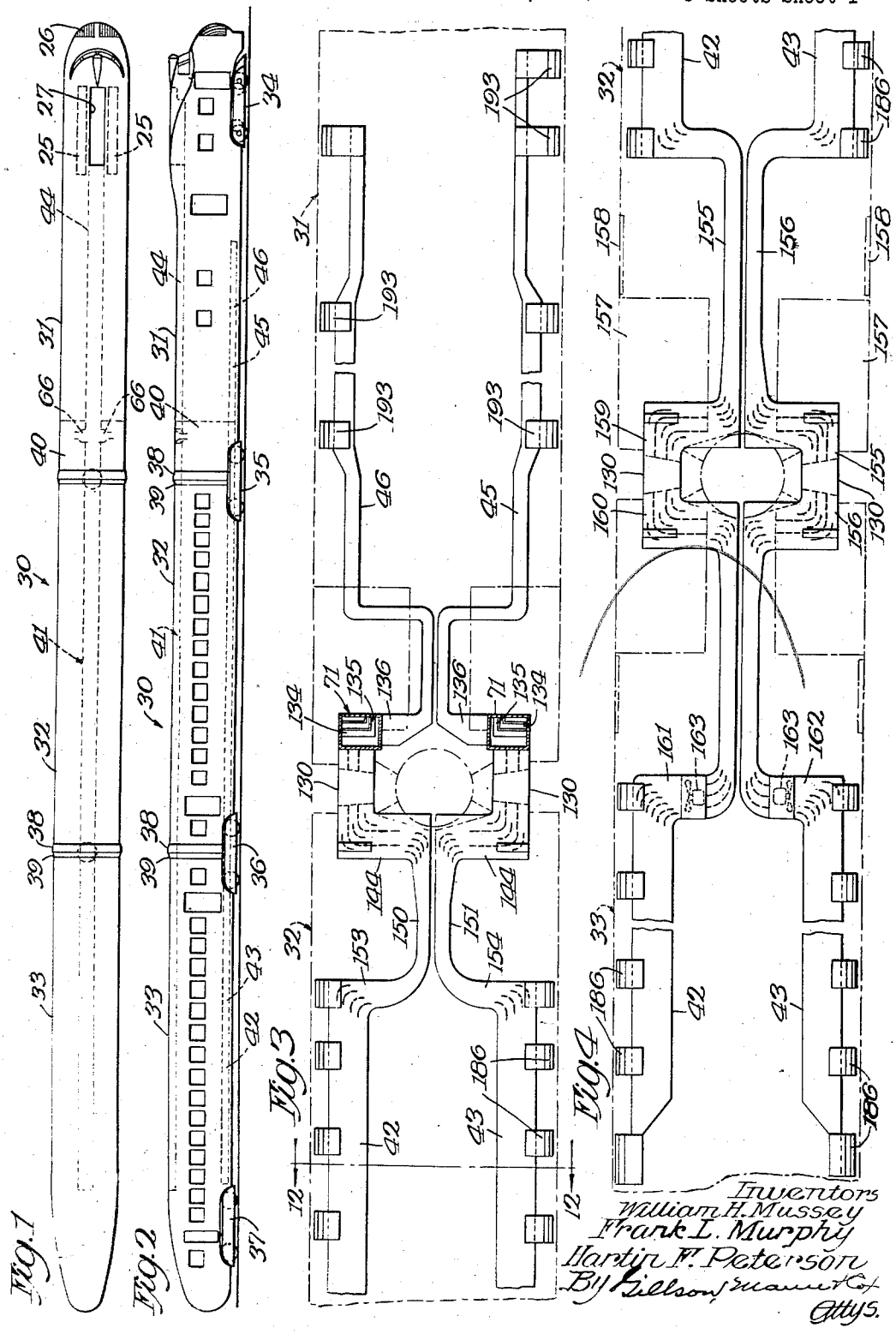
May 10, 1938. W. H. MUSSEY ET AL 2,116,538

AIR CONDITIONING SYSTEM

Filed March 26, 1934 9 Sheets-Sheet 1



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AIR CONDITIONING SYSTEM

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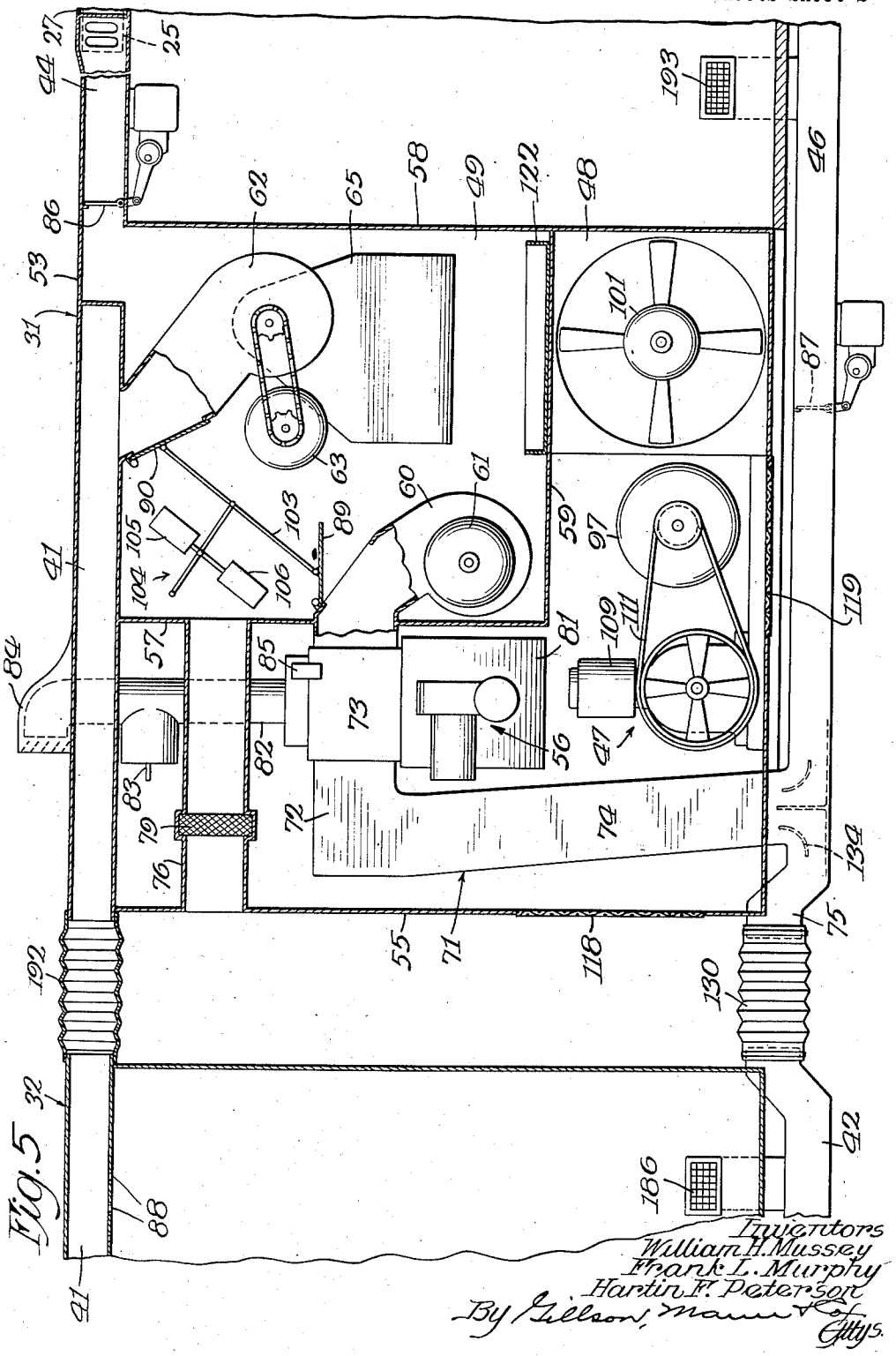



Fig. 5

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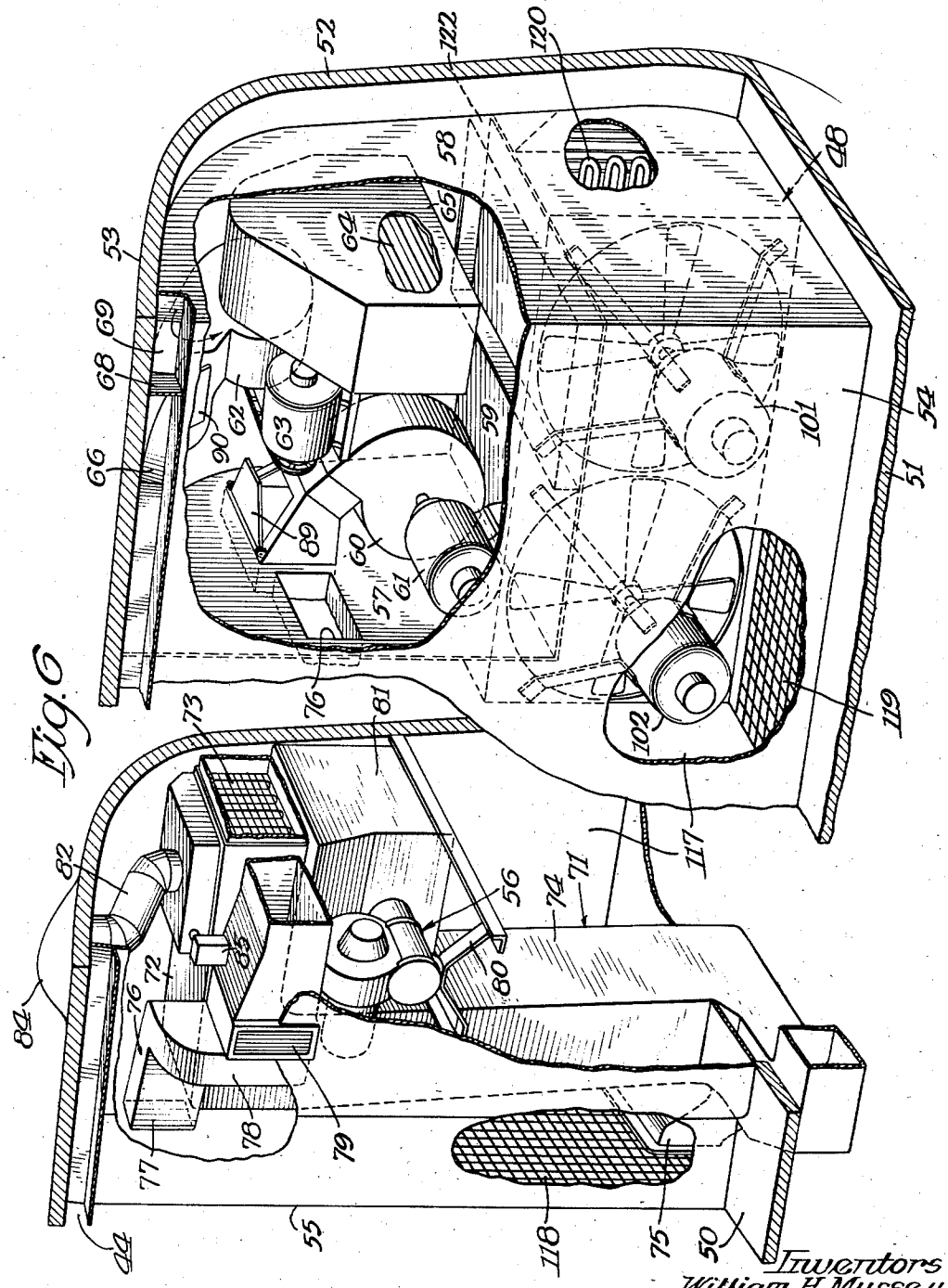



Fig. 6

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AIR CONDITIONING SYSTEM

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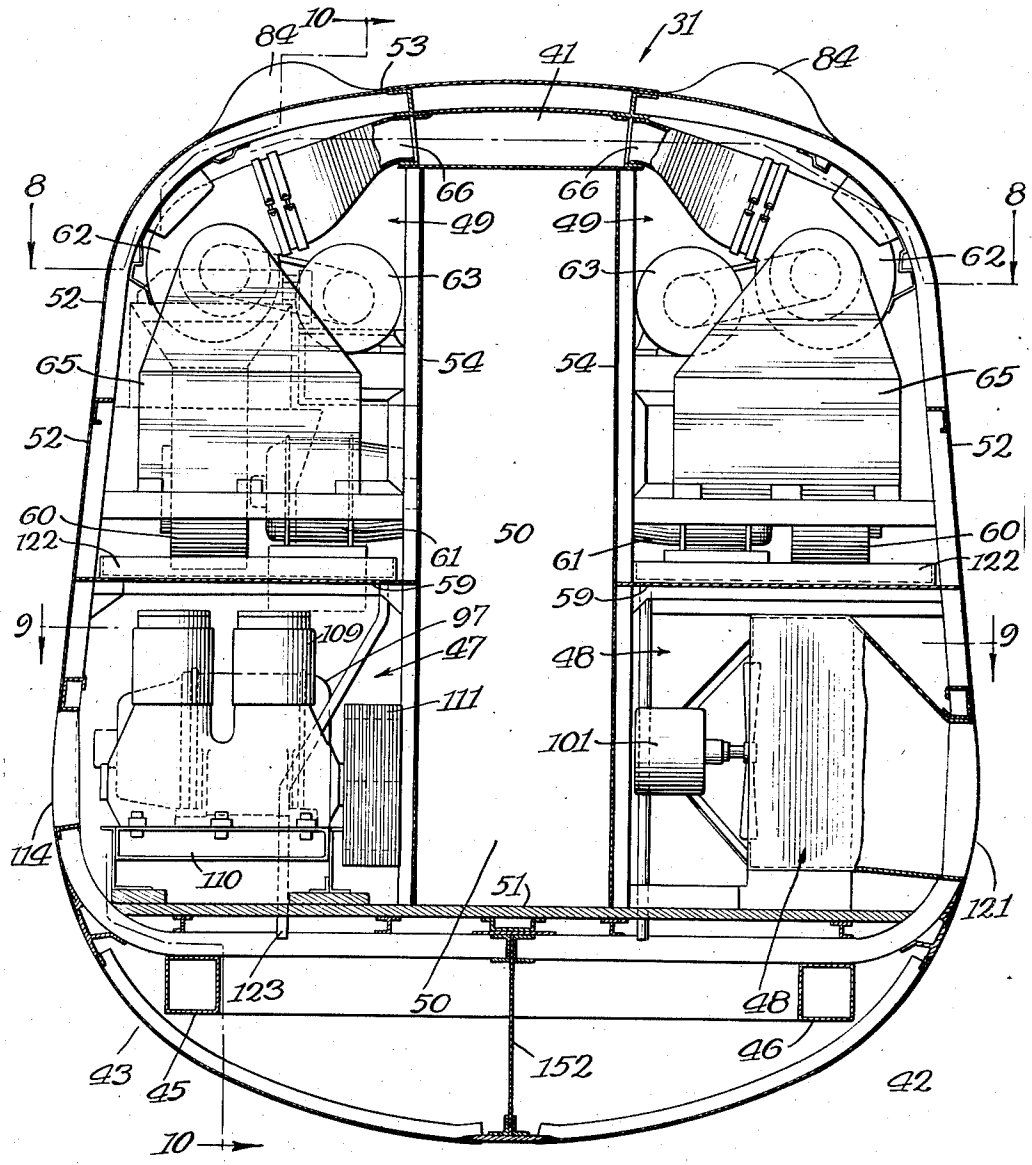



Fig. 7

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AIR CONDITIONING SYSTEM

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Fig. 8

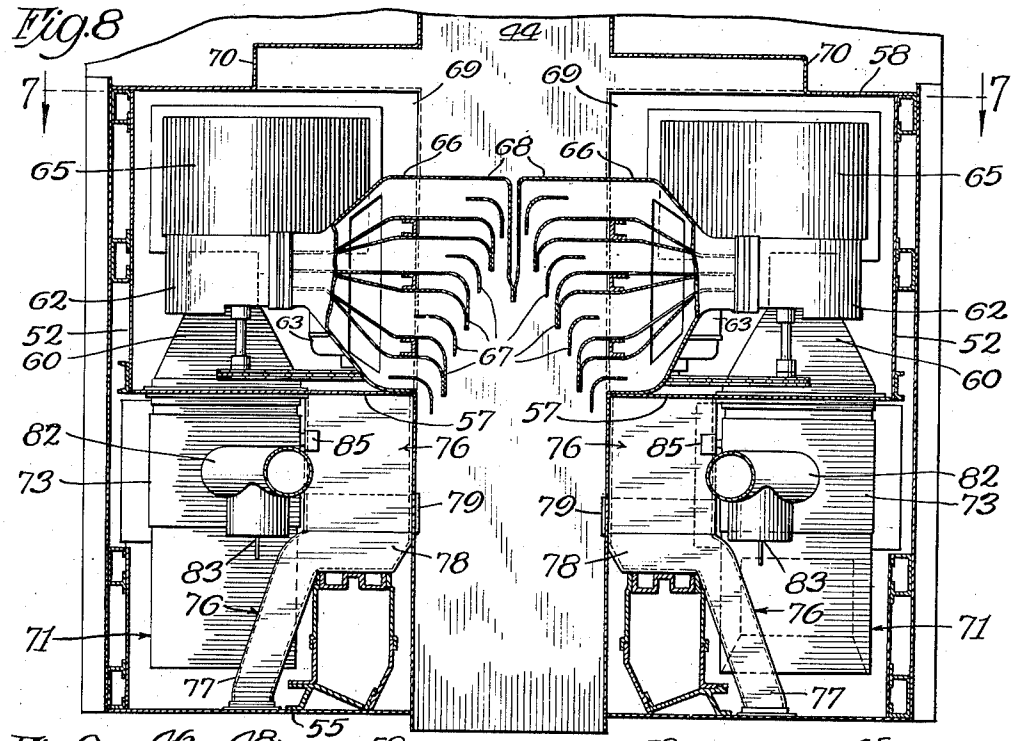
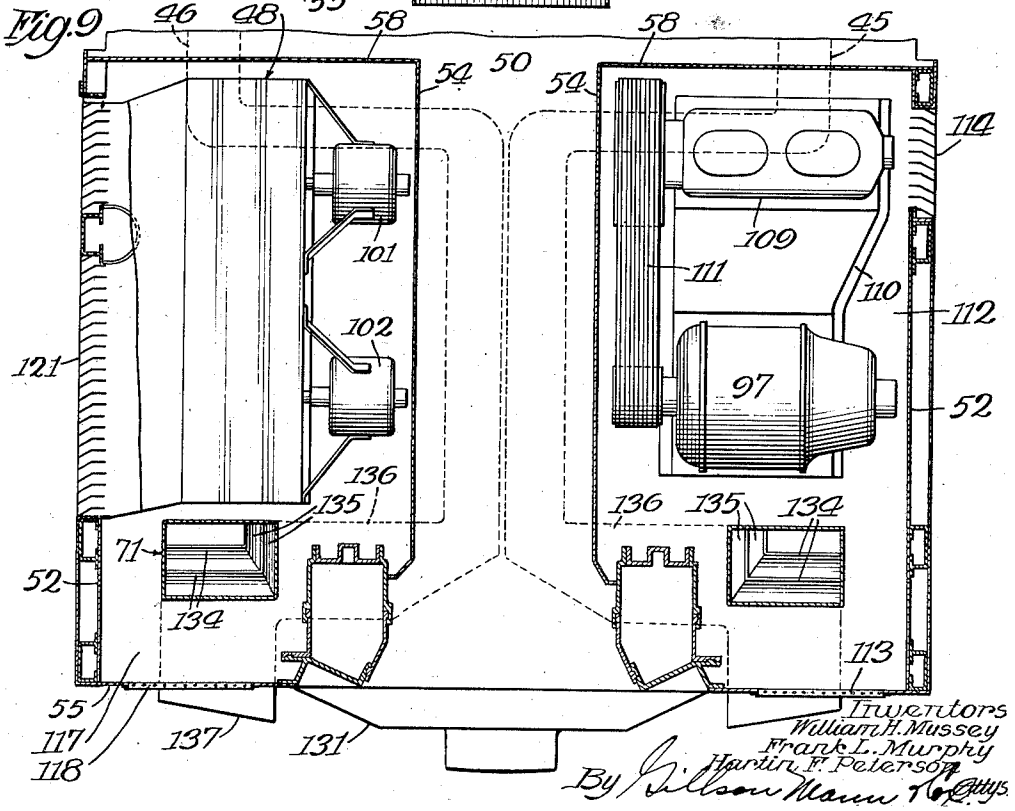



Fig. 9




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AIR CONDITIONING SYSTEM

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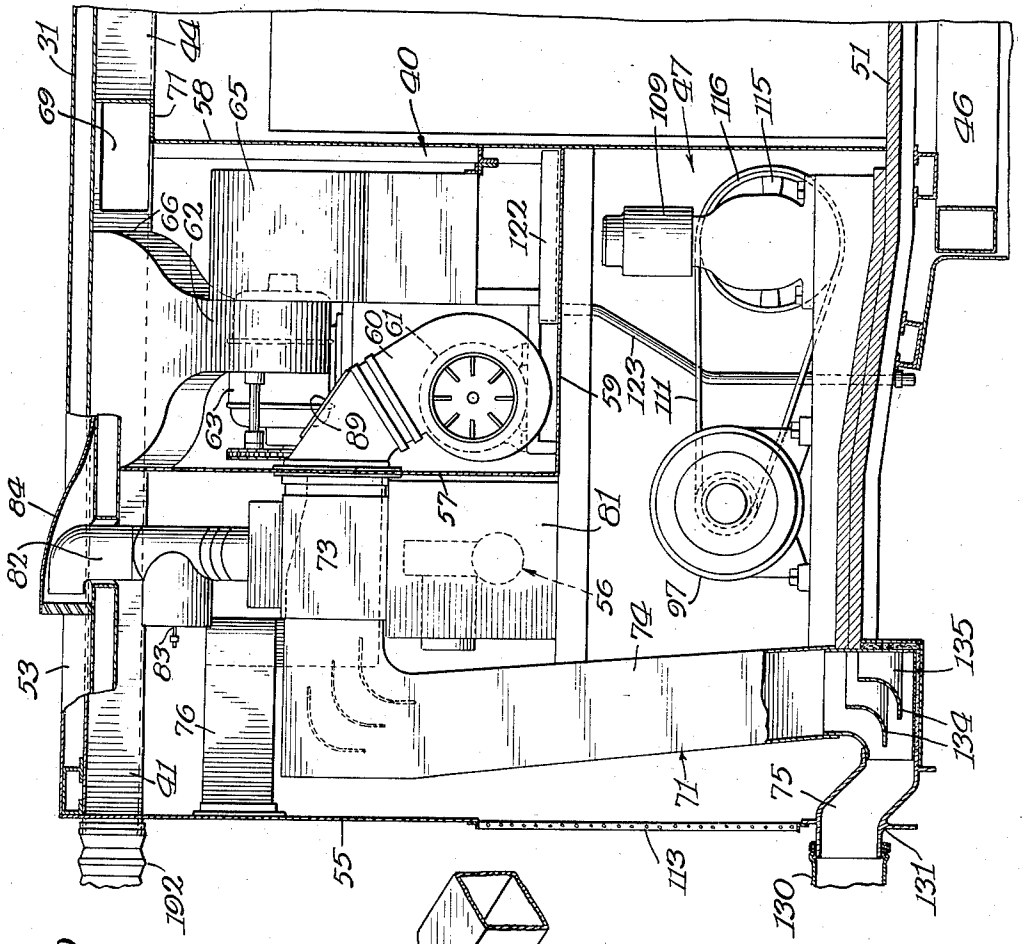



Fig. 10

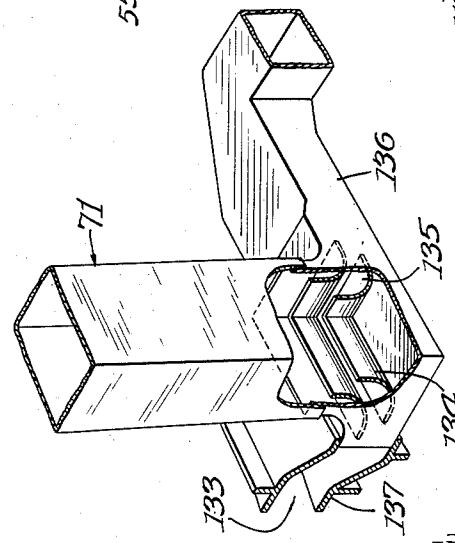



Fig. 11

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Fig. 12

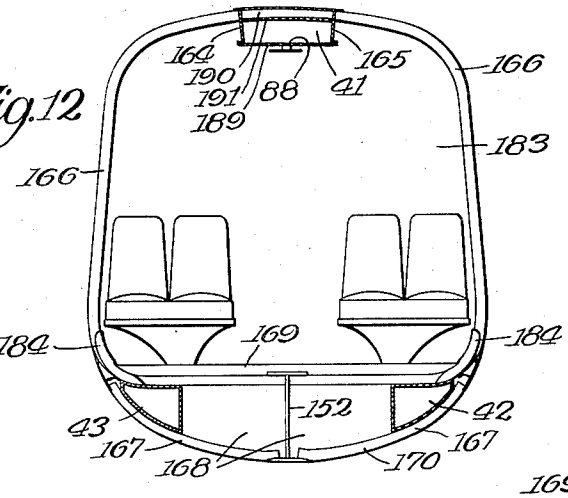



Fig. 13

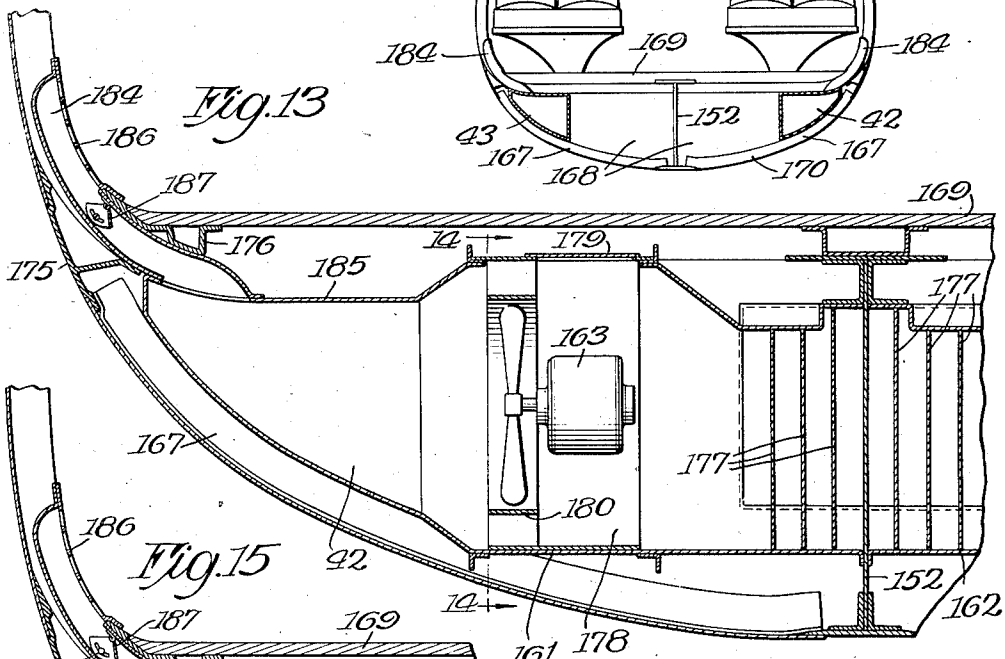



Fig. 15

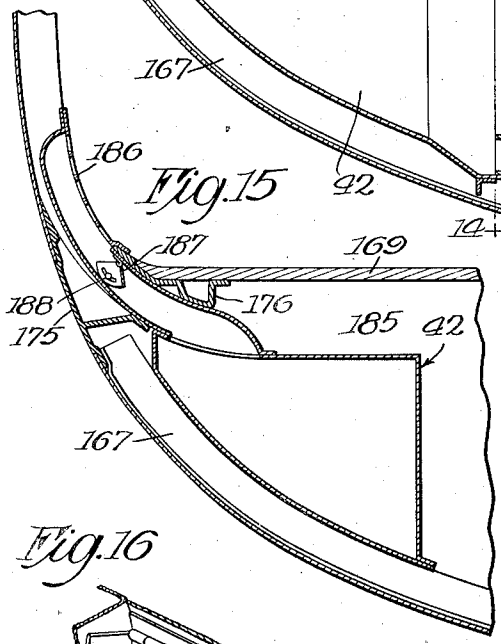



Fig. 16

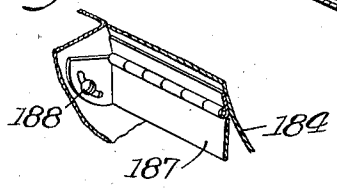
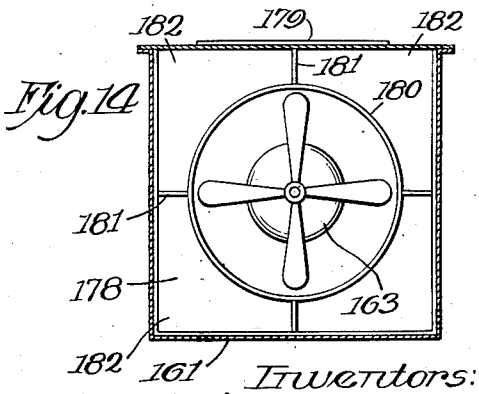



Fig. 14




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AIR CONDITIONING SYSTEM

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Fig. 17

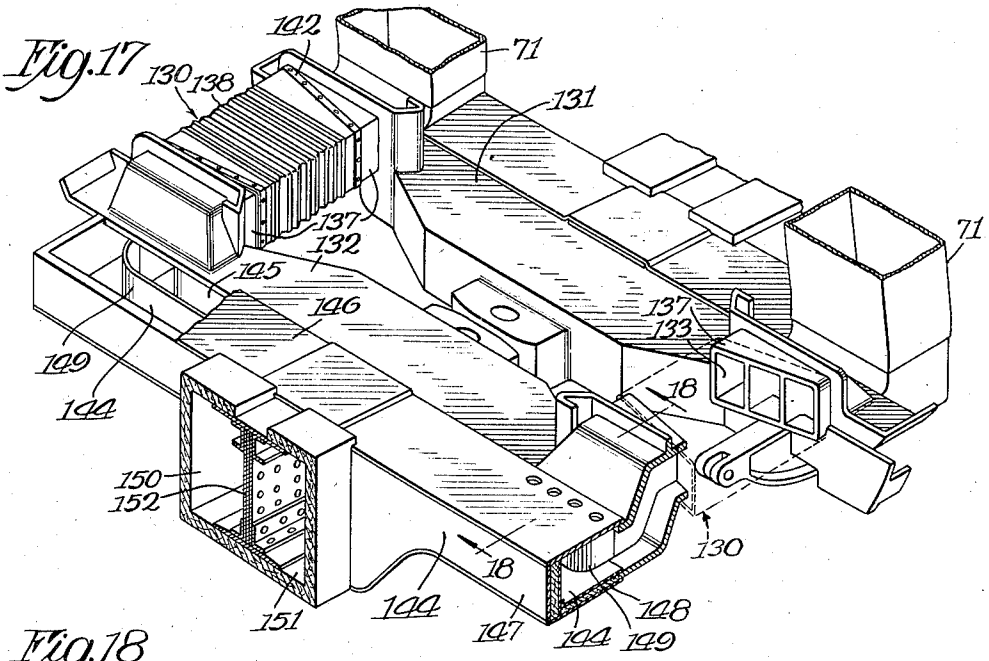



Fig. 18

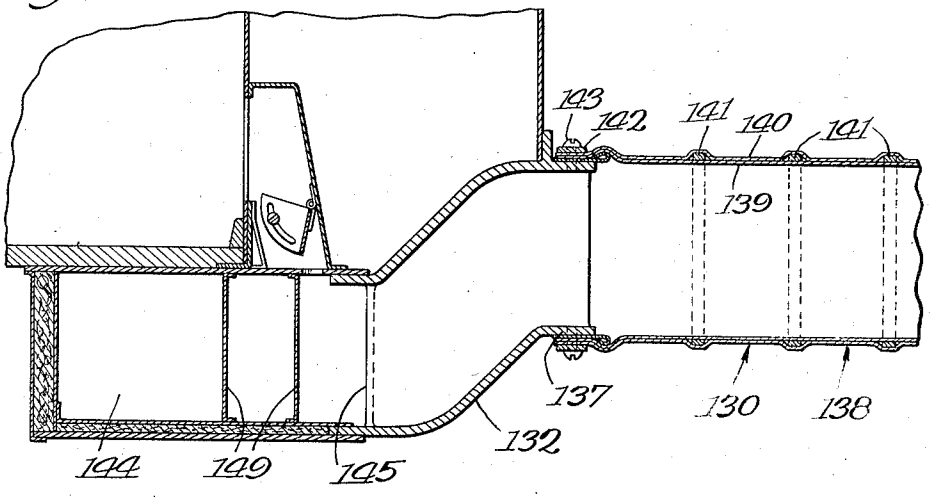
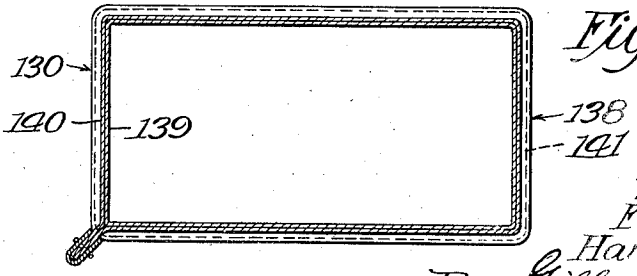



Fig. 19



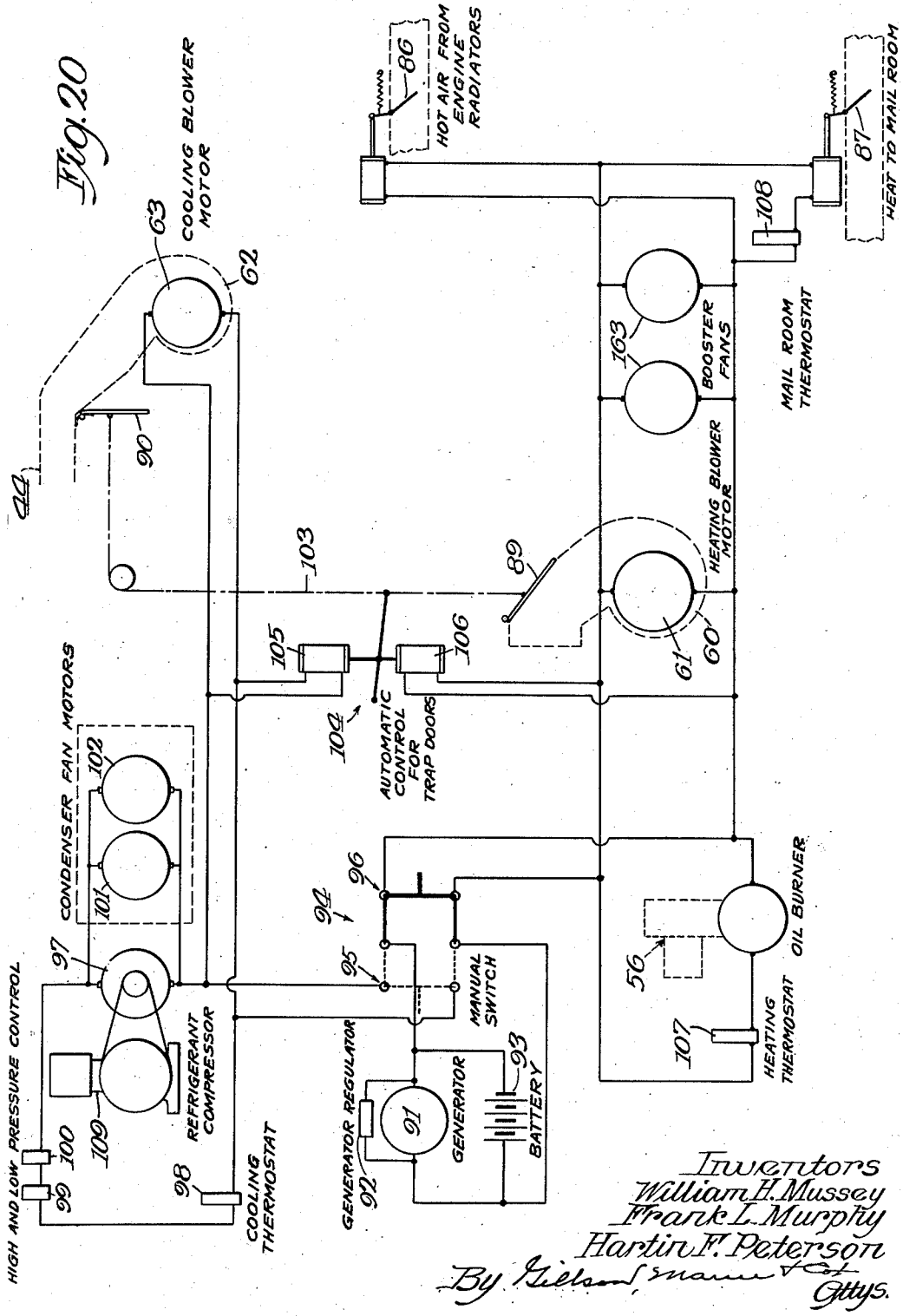

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AIR CONDITIONING SYSTEM

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Fig. 20




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Patented May 10, 1938 2,116,538

# UNITED STATES PATENT OFFICE

2,116,538

## AIR CONDITIONING SYSTEM

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Application March 26, 1934, Serial No. 717,421

7 Claims. (Cl. 257—7)

The principal object of this invention is to provide a complete air conditioning system for one or more railway car units, and to place the major portion of the apparatus in a centralized locality where it is readily accessible for inspection and servicing.

Further and other objects and advantages will become apparent as the disclosure proceeds and the description is read in conjunction with the accompanying drawings, in which:

Fig. 1 is a plan view of a three-unit articulated car used to illustrate a preferred embodiment of this invention;

Fig. 2 is a side, elevational view of the car;

Fig. 3 is a diagrammatic, fragmentary plan view of the lower duct system as applied to the first and second car units, the former being to the right in the figure;

Fig. 4 is a view corresponding to Fig. 3 but showing the lower duct system as it is applied to the rear portion of the second car and the front portion of the trailer car.

Fig. 5 is a schematic layout of the complete air conditioning system;

Fig. 6 is a diagrammatic, perspective view of a portion of the air conditioning apparatus, fragments being broken away to show the structure and arrangement of the various parts.

Fig. 7 is a transverse, sectional view taken on the line 7—7 of Fig. 8, and looking toward the rear of the car unit;

Fig. 8 is a horizontal, sectional view looking down upon the duplicate apparatus on opposite sides of the passageway, the section being taken on the line 8—8 of Fig. 7.

Fig. 9 is a horizontal, sectional view taken on the line 9—9 of Fig. 7;

Fig. 10 is a sectional view taken on the line 10—10 of Fig. 7, with fragments broken away.

Fig. 11 is a perspective view showing how a portion of the heated air stream is diverted to the mail and baggage rooms;

Fig. 12 is a typical transverse, sectional view showing the two lower ducts, the branch ducts, and the upper or overhead duct, the section being taken on the line 12—12 of Fig. 3;

Fig. 13 is a fragmentary, sectional view showing a booster fan installed in one of the lower ducts of the trailer car;

Fig. 14 is a sectional view through the duct in which the booster fan is installed, the section being taken on the line 14—14 of Fig. 13;

Fig. 15 illustrates the manner in which the branch ducts connect with the main floor ducts;

Fig. 16 is an enlarged detail perspective view showing the adjustable baffle for initially determining the amount of air which issues from each register;

Fig. 17 is a perspective view of the abutting end sills of adjacent car units showing particularly the manner in which the two lower ducts are carried from one car unit to another;

Fig. 18 is a fragmentary, sectional view taken on the line 18—18 of Fig. 7;

Fig. 19 is a transverse, sectional view through the flexible conduit which connects the ducts of adjacent cars.

Fig. 20 is a schematic layout of the system showing particularly the electrical control.

For the purpose of this disclosure, the invention has been shown applied to a three-unit articulated railway car, but it has innumerable other applications and is subject to many variations within the scope of the claims. Limitations, therefore, are not to be read into the claims unless required by the prior art.

The articulated car is indicated at 30 and is composed of a leading section 31, an intermediate section 32, and a trailer section 33. The car is supported on a motor truck 34, articulated trucks 35 and 36, and a trailer truck 37. The car is shaped to reduce wind resistance to a minimum and at the articulated joints between the car sections, metal shields 38 extend rearwardly from the preceding section and telescope over flexible canvas canopies 39 which are yieldingly extended to the fore to enclose the space between the car sections.

The air conditioning apparatus is located in the rear part 40 of the leading section 31 and the conditioned air is delivered to the passenger space in the sections 32 and 33 by an overhead or upper duct 41 when cooling of the passenger space is being effected, and by lower or floor ducts 42 and 43 (Fig. 12) when the passenger spaces are being heated. An overhead duct 44 (Fig. 10) in the leading section 31 delivers preheated air from the engine radiators to the air conditioning apparatus at the rear of the section when the system is being used for heating, and under the same circumstances, a pair of lower ducts 45 and 46 are utilized for delivering warm air to the mail and/or baggage rooms in the leading or motorized section of the car.

*The air conditioning apparatus*

The air conditioning apparatus located in the rear of the leading section 31 comprises in general a refrigerant compressor 47, a condenser 48, duplicate mixing chambers 49 (Fig. 5), the latter

being in the upper region of the car section on opposite sides of a central passageway 50. The refrigerant compressor 47 and the condenser 48 are also located on opposite sides of the same passageway (see Figs. 7–9).

A clear understanding of the apparatus may be best obtained by reference to Fig. 6 which shows in diagrammatic perspective the right hand portion of the apparatus shown in Fig. 7. The car floor is indicated at 51, the car side at 52, the car roof at 53, the side wall of the passageway at 54, and the rear end wall of the car section at 55 (Fig. 5).

The mixing or air conditioning chamber 49 (Fig. 5) of the duplicate air conditioning units is somewhat removed from the end wall 55 of the car section (Figs. 6 and 10) to provide a space for the heating apparatus, generally designated 56. Preferably an oil burner is used which employs the same grade of distillate that is used for running the Diesel engine that drives the motor truck 34. However, any suitable type of heating apparatus may be used.

The mixing chambers 49 are defined by end walls 57 and 58, the side wall 52 of the car section, the side panel 54 of the passageway, the roof 53 and a bottom wall or floor 59. Each mixing chamber houses a blower 60 with its motor 61, a cooling blower 62 with its motor 63, and a cooling coil 64 covered by a hood or shroud 65, which communicates with the intake of the blower 62. The cooling coil in the present case is connected directly with the condenser 48 making it what is generally known as a direct expansion coil. The connections between the compressor, the condenser and the refrigerating coil 64 are not shown for the connections are obvious to those skilled in the art.

The overhead duct 41 in the motorized section 31 is a continuation of the overhead duct in the intermediate and trailer sections 32 and 33, and communicates with the duplicate mixing chambers through branches 66 which connect with the exhaust side of the cooling blower 62 (Fig. 7). Deflector baffles 67 (Fig. 8) are employed in the branch ducts 66 to direct the air currents from the main duct to the branch ducts and vice versa with a minimum of turbulence.

The duct 44 which delivers preheated air from the engine radiators to the mixing chambers is also a continuation of the overhead duct 41, but the two are separated by a wall 68. The preheated air from the duct 44 is delivered into the mixing chambers under predetermined conditions through openings 69, the mixing chambers being slightly enlarged at the point of entry, as indicated at 70 (Fig. 8).

In the preferred embodiment of this invention, the engine radiators, generally designated 25 (Figs. 1, 2, and 5) are located adjacent to the roof of the car directly above the motor (not shown) which drives the car, and the radiators are cooled by air drawn through grills 26 in the car nose. This air is forced or allowed to flow over the radiators and most of it is discharged through the opening 27 into the atmosphere, but a part is directed rearwardly through the duct 44 to be used in heating the car. This may be accomplished in any suitable manner, and no claim is made herein to the precise manner of preheating air for the air conditioning apparatus, as this subject matter is claimed in a companion application.

The exhaust side of the heating blower 60 communicates with a duct, generally designated 71, having a horizontal portion 72 (Fig. 5) which passes through a heating coil 73 (Figs. 5 and 6) associated with the heating apparatus, and a vertical portion 74 which extends beneath the floor of the car and then merges with another horizontal portion 75 connected with other ducts leading to the several spaces that are to be conditioned.

A certain amount of fresh air is introduced into each mixing chamber through a duct 76 having its inlet through the end wall 55 of the car section. The duct for a portion of its length runs horizontally, but slightly diagonally of the car section, as indicated at 77 (Figs. 8 and 10), then proceeds toward the center of the car section and downwardly as indicated at 78 (Figs. 6 and 8) and then continues horizontally and parallel to the passageway 50 to the mixing chamber. A mechanical filter 79 is removably interposed in the fresh air duct 76 and is accessible from the passageway 50. Any other suitable type of filter may, of course, be used.

The oil burner illustrated in the present embodiment of the invention is mounted on a bracket 80 and is of the gun type. It discharges into a combustion chamber 81 and the heated gases then pass through the coils of the heating coil 73 much the same as a fire tube boiler. A stack 82 provided with a damper 83 removes the chilled gases from the heating coil 73 and delivers them to the outside atmosphere. The top of the stack projects through the roof and extends rearwardly, as shown in Fig. 10, and the projecting portion is covered by a streamline hood 84.

The oil burner has the usual controls, such for example as a pyrostat 85.

*Operation of the conditioning apparatus*

The operation of the apparatus may be best understood by reference to Fig. 5, and for convenience only one of the duplicate apparatus will be referred to in the following discussion, it being understood that the other one functions exactly the same.

In the summertime, the cooling blower 62 of each apparatus is constantly in operation and the heating blower 60 is dead. The duct 44 is closed off by a motorized damper 86 to prevent heated air from being drawn into the mixing chamber from the engine radiators, and motorized dampers 87 (Fig. 5) in the ducts 45 and 46 exclude the mail and baggage rooms from being serviced by the cooling apparatus.

The cooling blower draws air from the mixing chamber through the hood 65 and over the cooling coil 64 and delivers the cooled air to the overhead duct 41 which extends rearwardly through the intermediate and trailer sections, and communicates with the passenger spaces through suitable grills 88 (Fig. 12). The subatmospheric pressure produced in the mixing chamber by the blower 62 draws both fresh and recirculated air into the mixing chamber, the former through the fresh air duct 76, and the latter through the duct 71 which communicates with one of the lower ducts of the intermediate and trailer sections 32 and 33.

The recirculated air passes through the heating coil 73 which, of course, is not in operation, and enters the mixing chamber through a trap door 89 so as to by-pass the heating blower. The trap door 89 is always open when the cooling blower is in operation, but is closed whenever the apparatus is used for heating. Likewise, a

similar trap door 90 is closed when the cooling blower is in operation, but open when the heating blower is in operation.

In the winter time, when it is desired to heat the car, the cooling apparatus is either manually or automatically turned off and the heating apparatus placed in operation. This means that the oil burner will be operating, controlled of course by a suitable thermostat, the heating blower will be functioning, the damper 86 will be open to allow pre-heated air from the engine radiator to enter the mixing chamber, the trap door 90 will be opened, the trap door 89 closed, and the damper 87 will be open to permit heat to be delivered to the mail and baggage rooms. The suction of the heating blower will draw air through the fresh air intake 76, and recirculated air through the overhead duct 41, the latter air by-passing the cooling blower 62 by entering the mixing chamber through the trap door 90. The air drawn from the mixing chamber by the blower 60 (which consists of fresh air, recirculated air and pre-heated air from the engine radiators) passes through the heating coil 73 and is then forced through one of the lower ducts in the car sections where it is delivered into the proper spaces.

*Control of the apparatus*

The inter-relationship of the elements of the air conditioning aparatus is shown diagrammatically in the wiring diagram of Fig. 20. The source of power in the present embodiment of the invention is a generator 91 preferably driven directly from the Diesel engine which operates the car, although it may be driven by an auxiliary power unit, or from the car axle, or by any other suitable means. The usual generator regulator is indicated at 92 and a battery at 93. The capacity of the generator and the size of the battery will vary to suit individual conditions. The generator and the battery, which, as customary, are joined in parallel, have leads connecting with the double throw switch, generally indicated at 94, one side of the switch 95 controlling the cooling apparatus, and the other side 96, the heating apparatus. Of course the change from one to the other may be effected by automatic means, if desired.

The compressor motor 97 is in series with the cooling thermostat 98 located in one of the spaces that is being cooled and also in series with high and low pressure switches 99 and 100 which control the maximum and minimum pressures of the refrigerant. The condenser fan motors 101 and 102 are connected in parallel with the compressor motor 97.

The cooling blower motor 63 connects directly with the side 95 of the double-throw switch 94 so that it operates continuously when the switch is set for cooling.

The trap doors 89 and 90 may be operated either manually, or automatically, and in the latter case, the two may be interconnected, as indicated at 103 and their position controlled by any suitable means. The means, generally indicated at 104 in Fig. 6, merely illustrates the principle of the control for whenever the coil 105 is energized, the trap door 90 will be closed, and the trap door 89 will be opened, and whenever the coil 106 is energized, the reverse will occur. It will be clear from the diagram of Fig. 20, that the coil 105 is energized as long as the switch 94 is in the dotted line position, and similarly the coil 106 is energized whenever the switch is in the full line position.

The oil burner is connected in series with a heating thermostat 107 located in one of the passenger spaces and is intermittently operated in response to the thermostat. The heating blower motor 61 is connected directly with the right-hand side 96 of the switch 94 and, therefore, operates as long as the switch blade is thrown to heating position.

The damper 86 in the duct 44 is connected in parallel with the heating blower, as is also the damper 87 in the warm air duct leading to the mail and baggage rooms. The latter damper, however, is connected in series with a thermostat 108 that is located in the mail room.

*Refrigerating apparatus per se*

The refrigerator compressor 109, which may be either air-cooled or water-cooled, is mounted on a suitable base 110 (Fig. 7) and is driven by a multiple V-belt drive 111 (Fig. 5) from the motor 97. The motor and compressor are cooled at least in part by a current of air which enters the compressor compartment 112 through a grill 113 (Fig. 10) at the end of the car and is exhausted through the side of the car, as indicated at 114 (Fig. 9). A fan 115 mounted interiorily of the pulley 116 which drives the compressor induces the draft.

The condenser fan motors 101 and 102 in the condenser compartment 117 draw air through a grill 118 at the end of the car (Fig. 6) and through a floor grill 119, and then force the air over the condenser coil 120 and out through the side of the car, as indicated at 121 (Fig. 7).

Beneath the refrigerating coil 64 in each mixing chamber is a drip pan 122 which collects the moisture resulting from dehumidification of the air and discharges it through a drain 123 (Fig. 10).

*Air distribution system*

The description thus far has dealt with the method of conditioning the air and preparing it for distribution to the passenger spaces. It has been shown how warm air is delivered downwardly in the ducts 71 when the car is to be heated, and how chilled air is forced rearwardly through the duct 41 when the car is to be cooled.

Because of the articulated joint between adjacent car sections, it is necessary to carry the warm air from the leading section 31 to the intermediate section 32 in duplicate conduits 130, one being on each side of the joint. By referring to Fig. 17 which illustrates a pair of end sills 131 and 132, the former for convenience being considered the rear end sill of the leading car section 31, it will be seen that the air ducts 71 connect with the rear side of the end sill 131 and direct the warm air through partitioned channels 133 which are formed in the end sill casting. Deflectors 134 direct the major portion of the air stream through the channels 133, but other deflectors 135 placed at right angles to the former serve to direct a portion of the air stream inwardly (see Fig. 3) along ducts 136 formed along the rear wall of the end sill for use in heating the mail and baggage rooms. (Fig. 11 also.)

The end sills 131 and 132 are equipped with extensions 137 at the points where the partitioned channels or conduits 133 emerge from the end sills. Flexible diaphragms 138 (Fig. 18) consisting of two layers 139 and 140 of rubberized fabric, separated at intervals by metal rings 141

are adapted to telescope over the projections 137 and be secured thereto by retaining rings 142 held in place by screws 143. The diaphragms act more or less as bellows in accommodating relative movement between the car sections.

The warm air upon entering the channels 133 in the end sill casting 132 of the intermediate car section is carried rearwardly to ducts 144 extending along the rear or inside face of the end sill casting (Fig. 17). These ducts are defined by the rear wall 145 of the end sill, an anti-telescoping plate 146 above, and insulated walls 147 and 148 on the side and below. Deflectors 149 serve to direct the air from the channels 133 to the ducts 144 with a minimum of effort.

The ducts 144 communicate with ducts 150 and 151 on opposite sides of the center sill 152. These two latter ducts have insulated top, bottom, and side walls, as shown in Fig. 17, and are separated by the center sill 152. The rear ends of the ducts 150 and 151 join with outwardly directed ducts 153 and 154 (Fig. 3), respectively, which in turn communicate with the longitudinal floor ducts 42 and 43 running along opposite sides of the car below the floor level.

At the rear of the intermediate car section 32, the longitudinal floor ducts 42 and 43 converge toward the center sill as shown in Fig. 4, thus duplicating the duct arrangement at the front end of the car section, with the exception that the portions 155 and 156 that parallel the center sill are somewhat longer because of the lavatory spaces 157 and doors 158 at this end of the car.

The arrangement for carrying the floor ducts from the intermediate car section 32 to the trailer section 33 corresponds exactly with the arrangement previously described for carrying the ducts from the leading section to the intermediate section, it being understood, of course, that the duct 71 is omitted and that the rear end sill casting 159 of the intermediate car section 32 and the front end sill casting 160 of the trailer car section 33 are both identical with the end sill casting 132 at the front end of the intermediate car section.

In the trailer section 33, the outwardly directed portions 161 and 162 of the floor ducts are slightly enlarged (see Figs. 4 and 13) to accommodate booster fans 163. These fans operate only when the car is being heated and they insure that sufficient quantity of heated air reaches the trailer section.

The details of the floor and overhead duct installations are shown in Figs. 12–16 inclusive. As will be seen in Fig. 12, the cross sectional shape of the car is generally ovate, and the essential parts of the car framing, for the purpose of this disclosure, include the center sill 152, top sills 164 and 165, ribs 166 which join the top sills 164 and 165 with the top portion of the center sill, side sills 175, longitudinal framing members 176, and arcuate angles 167 which connect the ribs with the lower portion of the center sill and form a space 168 between the floor 169 of the car and the belly 170.

The floor ducts 42 and 43 are substantially triangular in cross section with one side slightly curved to conform with arcuate angles 167 forming the belly of the car. The forward ends of the floor ducts 42 and 43 in the trailer section 33 join with the inwardly extending portions 161 and 162 in a manner best shown in Fig. 13. Deflectors 177 direct the warm air which is travelling rearwardly through the ducts 155 and 156 laterally into the transversely extending ducts 161 and 162, each of which is equipped with an enlarged portion 178 for housing a booster fan 163. The enlarged portion or housing is square in cross section (see Fig. 14) and has an opening above to provide access to the fan motor. The opening is normally closed by a cover plate 179.

The booster fan and its motor are mounted centrally within the housing and the fan rotates within a cylinder 180 supported by webs 181 reaching from the side walls of the housing. The area within the cylinder should be substantially equal to the sum of the areas of the spaces 182 so that when the air conditioning system is being operated for cooling (in which case the floor duct acts as a return duct), the fan will not impede the flow of air forwardly through the floor ducts. Obviously the spaces 182 do not interfere with the functioning of the booster fan when it is operating to force heated air rearwardly through the ducts.

The floor ducts 42 and 43 communicate with the passenger space 183 through a plurality of branch ducts 184, the latter connecting with the top side 185 of the floor ducts and being supported in place by the longitudinal framing members 175 and 176. The branch ducts are provided with grilled openings 186 or with any other suitable type of discharge opening.

The volume of air which issues from any particular branch duct is determined empirically by regulating a damper 187, and once the proper volume has been determined, the damper is locked in place by a screw 188.

The overhead duct 41 has for its side walls the top sills 164 and 165 and for its bottom wall a plate 189 having a plurality of openings 88 communicating with the interior of the car. The top sills are held in spaced relation by spacers 190 which are placed at intervals corresponding to the spacing of the ribs 166. A top sheet 191 fastened to the bottoms of the spacers 190 completes the overhead duct 41.

The overhead duct 41 is carried from one car section to another in a straight line as the top sills 164 and 165 extend the full length of the car sections (at least in so far as they are pertinent to the air distribution system.) A flexible diaphragm 192 (see Fig. 5) which is similar in all respects to the diaphragm between the end sill ducts connects the overhead ducts 41 between adjacent car sections.

The mail and baggage rooms are heated by the floor ducts 45 and 46 which are equipped with branch ducts 193 (Fig. 5) identical in all respects with the branch ducts 184 of the floor ducts 42 and 43 in the intermediate and trailer sections.

What we claim, therefore, is:

1. An air conditioning system for railway cars comprising a conditioning chamber, upper and lower ducts in communication with the space to be conditioned and with the conditioning chamber, heating and refrigerating units in series with the ducts and the chamber, a blower for each of said units, one for circulating air through the ducts and the chamber in one direction, and the other for circulating air through the ducts in the other direction, and means for by-passing the air around the blower not in operation.

2. An air conditioning system for railway cars comprising a conditioning chamber, upper and lower ducts in communication with the space to be conditioned and with the conditioning cham-

ber, heating and refrigerating units in series with the ducts and the chamber, a blower for each of said units, one for circulating air through the ducts and the chamber in one direction, and the other for circulating air through the ducts in the other direction, and means for by-passing the air around the blower not in operation, both of said blowers being located within the conditioning chamber.

3. An air conditioning system for a vehicle driven by an internal combustion engine, a cooling radiator associated therewith, said system comprising a conditioning chamber, heating and refrigerating units associated with the chamber, means for circulating air through the ducts in a predetermined direction, a warm air duct leading from the radiator to the chamber for supplying preheated air to the chamber when the heating unit is in operation, and means for closing off said warm air duct when the refrigerating unit is in operation.

4. An air conditioning system for a vehicle driven by an internal combustion engine, a cooling radiator associated therewith, said system including a passage leading from the radiator communicating with the passenger space to be conditioned, means for moving air through said passage, an auxiliary heating coil interposed between the engine radiator and the space to be conditioned in the path of said air, and means independent of said engine for heating said coil.

5. An air conditioning system for a vehicle driven by an internal combustion engine, a cooling radiator associated therewith, said system including a passage leading from the radiator communicating with the passenger space to be conditioned adjacent one wall of said space, means for moving air through said passage, an auxiliary heating coil interposed between the engine radiator and the space to be conditioned in the path of said air and energized independently of said engine, and means for withdrawing air from a point vertically spaced and adjacent a wall opposite the first-named wall and mixing air drawn from the passenger space with air that has passed through the engine radiator prior to passing it through the auxiliary heating coil.

6. In combination with a railway car, air ducts in communication with the passenger space, air conditioning apparatus including a mixing chamber having two conduit openings adapted to connect with the ducts, a cooling surface in the chamber, means for forcing air through the chamber into one of the ducts, and an oil heater outside of the chamber, and a heat exchange device for transferring heat units derived from the oil burner to the air passing through the chamber.

7. In combination with an enclosure, air conditioning apparatus for raising or lowering the temperature of the air passing through the apparatus, the upper and lower ducts communicating with the enclosure and with the apparatus, a blower for forcing air through the ducts in one direction, a second blower for forcing air through the ducts in the opposite direction, and means for by-passing air around said first blower when the second blower is in operation.

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