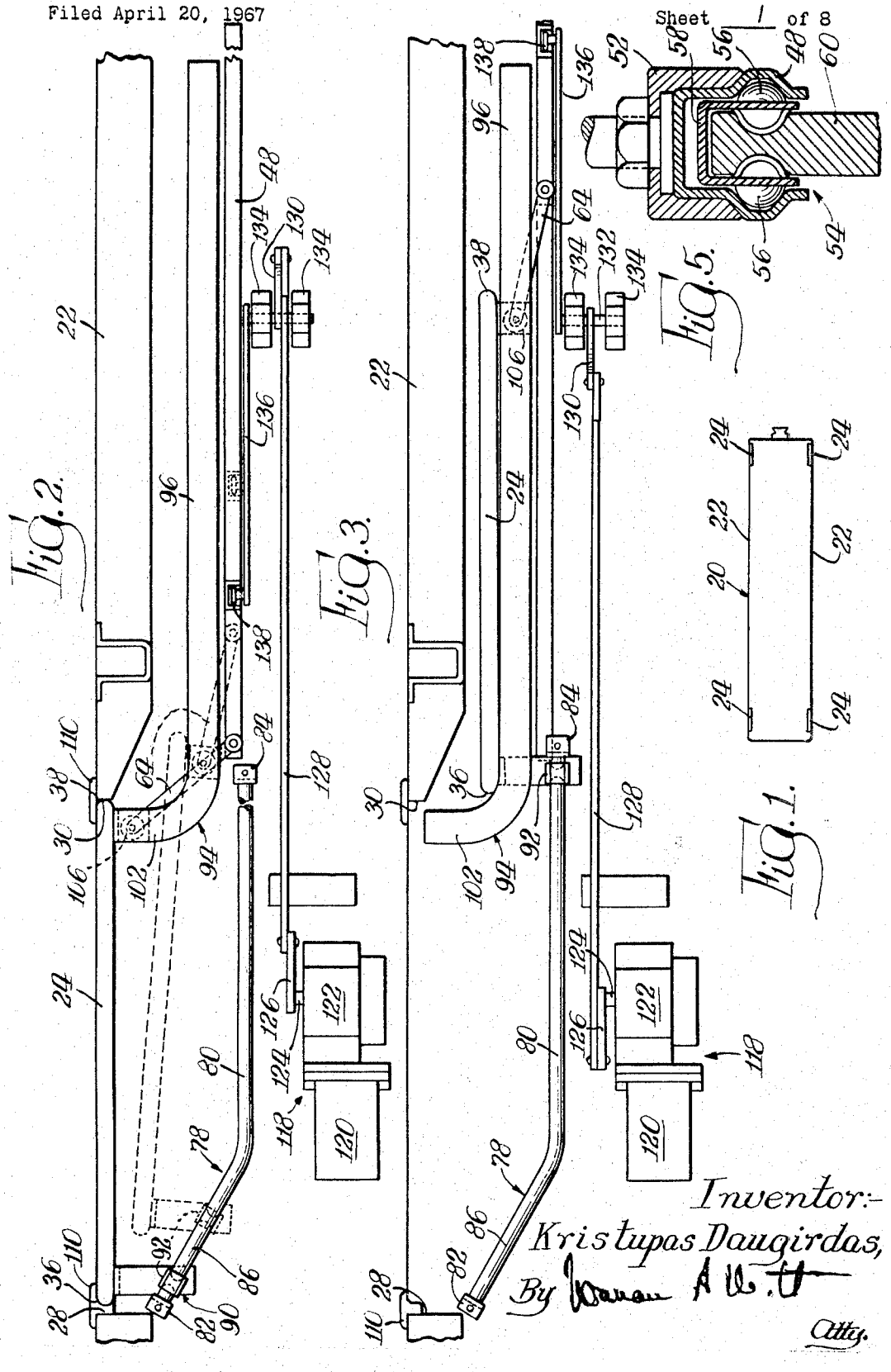
July 8, 1969 K. DAUGIRDAS 3,453,778

PLUG DOOR MECHANISM

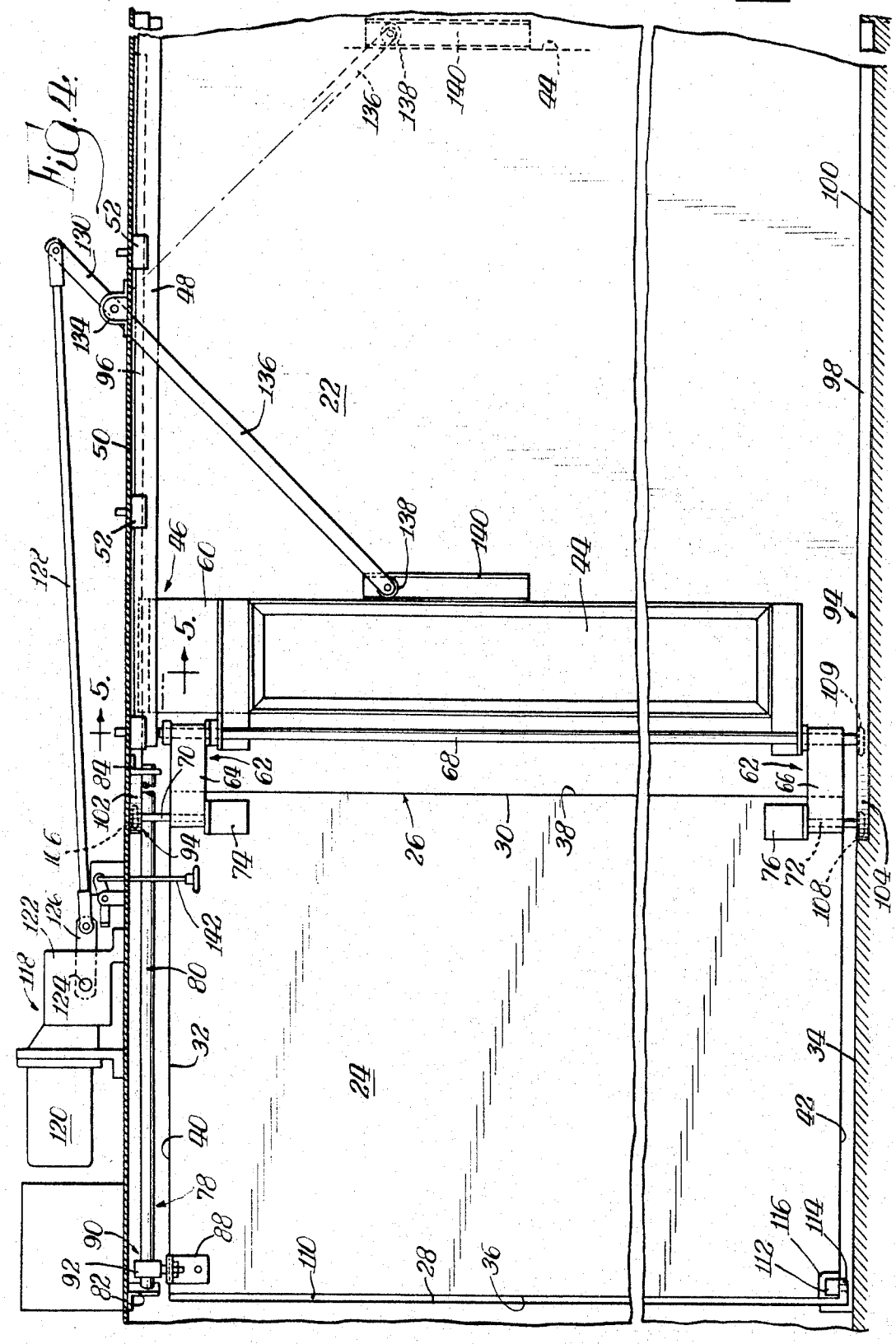
Filed April 20, 1967 Sheet 1 of 8



July 8, 1969 K. DAUGIRDAS 3,453,778

PLUG DOOR MECHANISM

Filed April 20, 1967 Sheet 2 of 8



July 8, 1969 K. DAUGIRDAS 3,453,778

PLUG DOOR MECHANISM

Filed April 20, 1967 Sheet 3 of 8

Fig. 6.

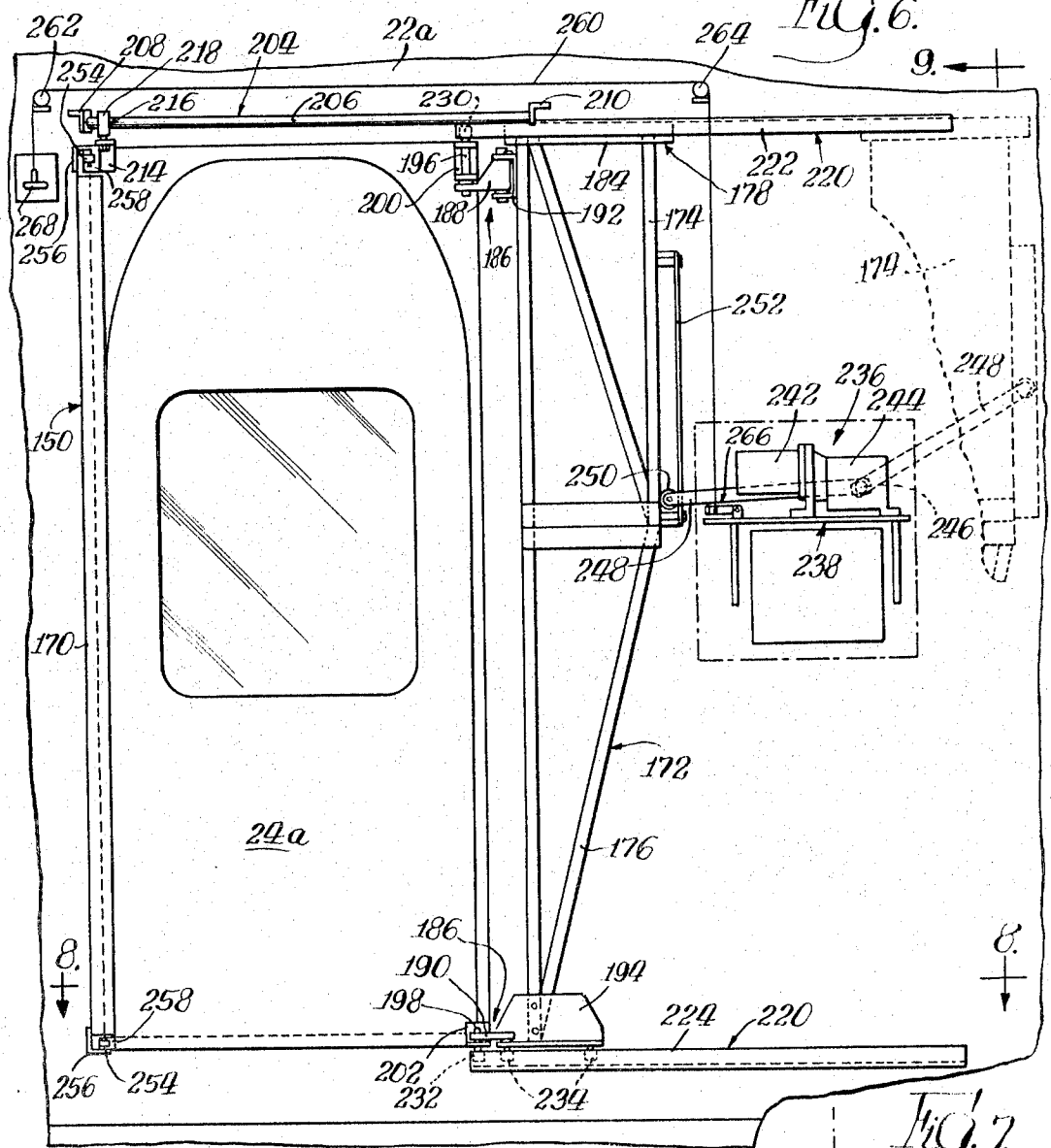


Fig. 7

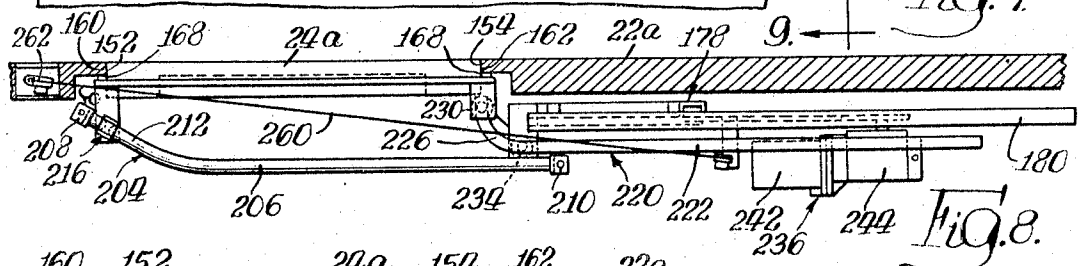
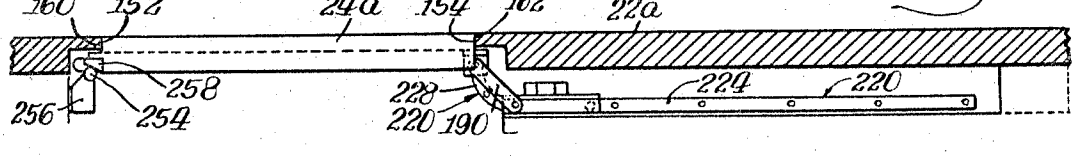


Fig. 8.



July 8, 1969 K. DAUGIRDAS 3,453,778

PLUG DOOR MECHANISM

Filed April 20, 1967 Sheet 4 of 8

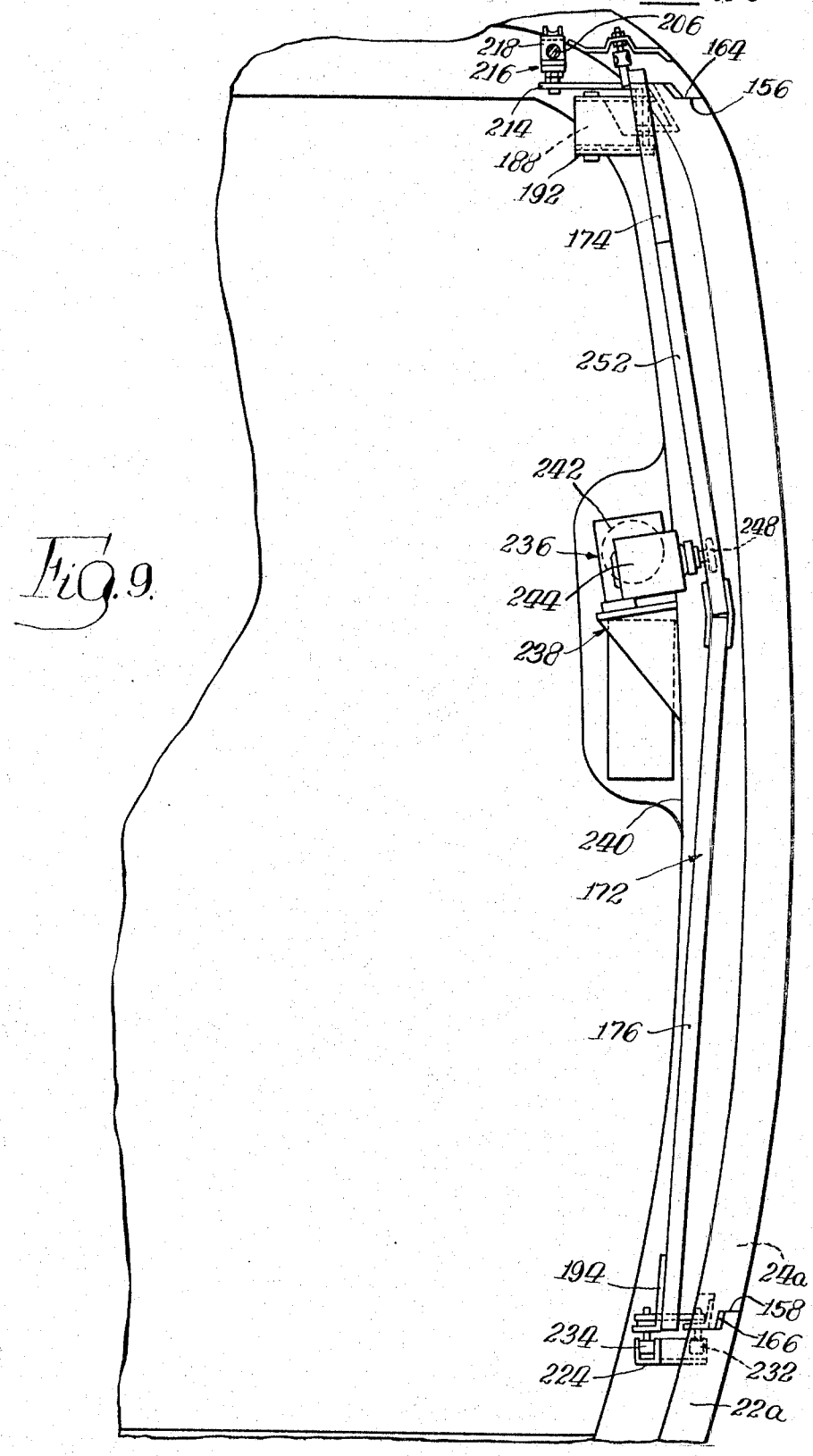
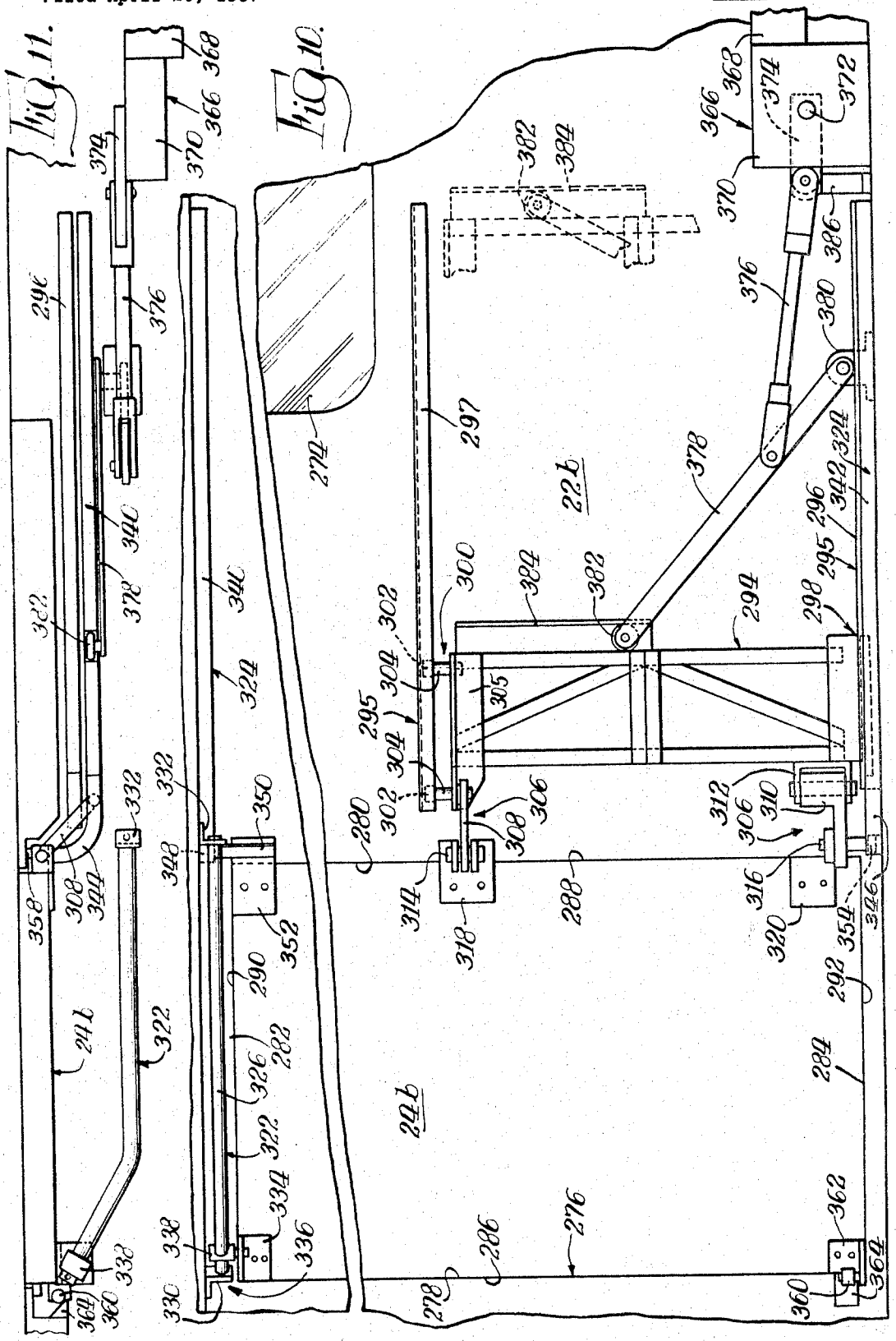


Fig. 9.

July 8, 1969 K. DAUGIRDAS 3,453,778

PLUG DOOR MECHANISM

Filed April 20, 1967 Sheet 5 of 8

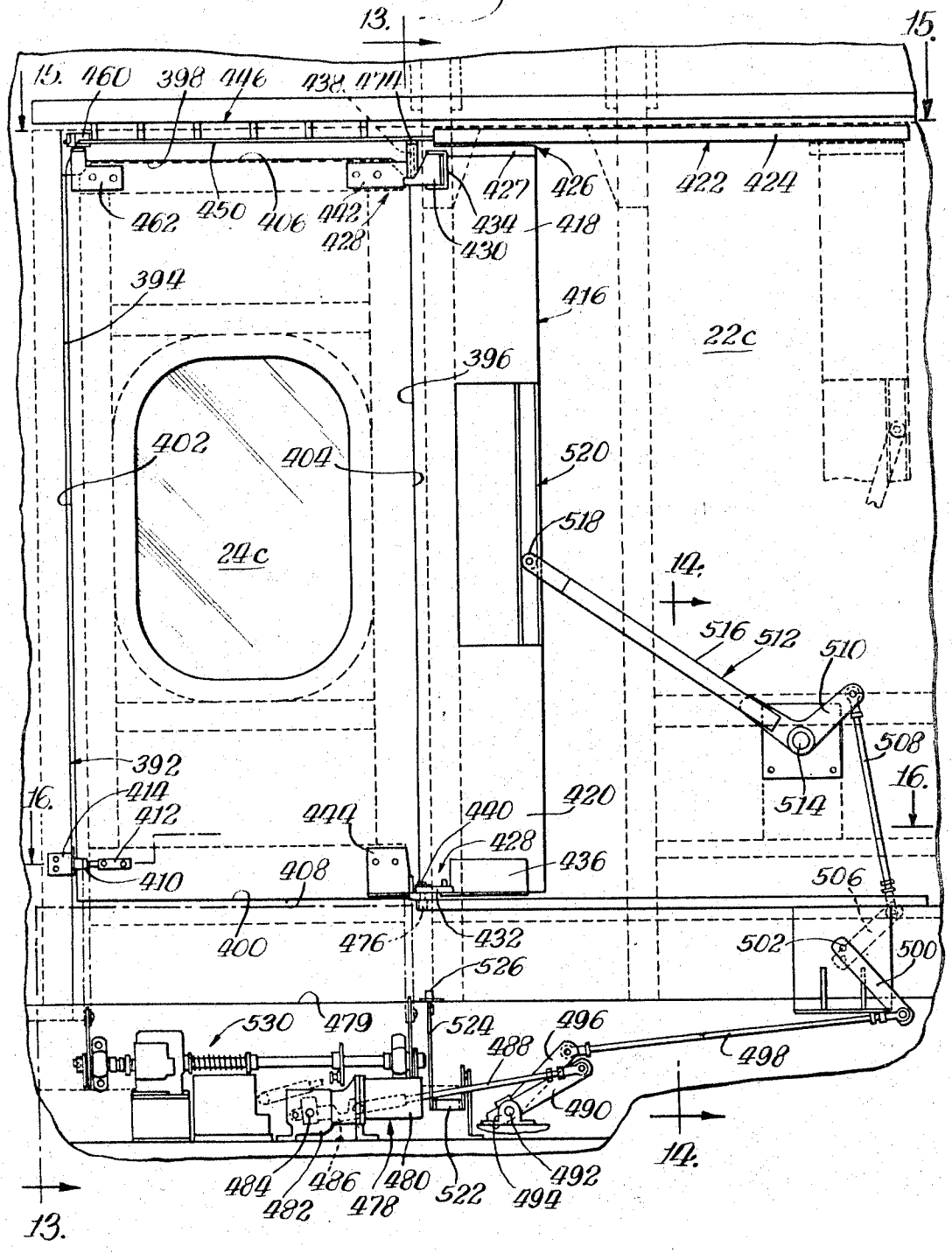


July 8, 1969 K. DAUGIRDAS 3,453,778

PLUG DOOR MECHANISM

Filed April 20, 1967 Sheet 6 of 8

Fig. 12.



July 8, 1969 K. DAUGIRDAS 3,453,778

PLUG DOOR MECHANISM

Filed April 20, 1967 Sheet 7 of 8

Fig. 14.

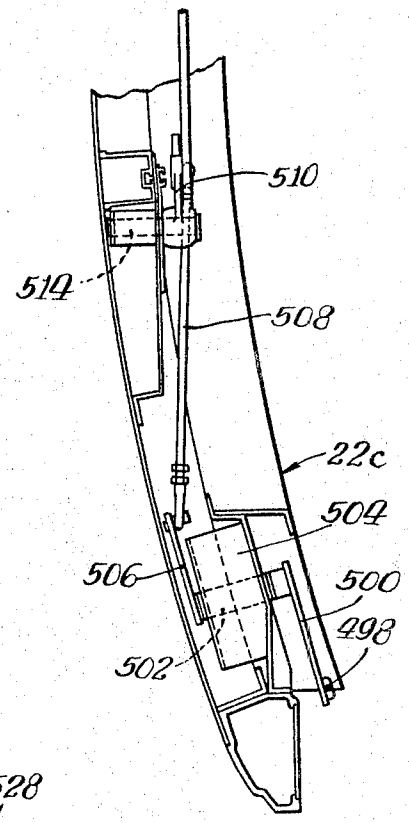
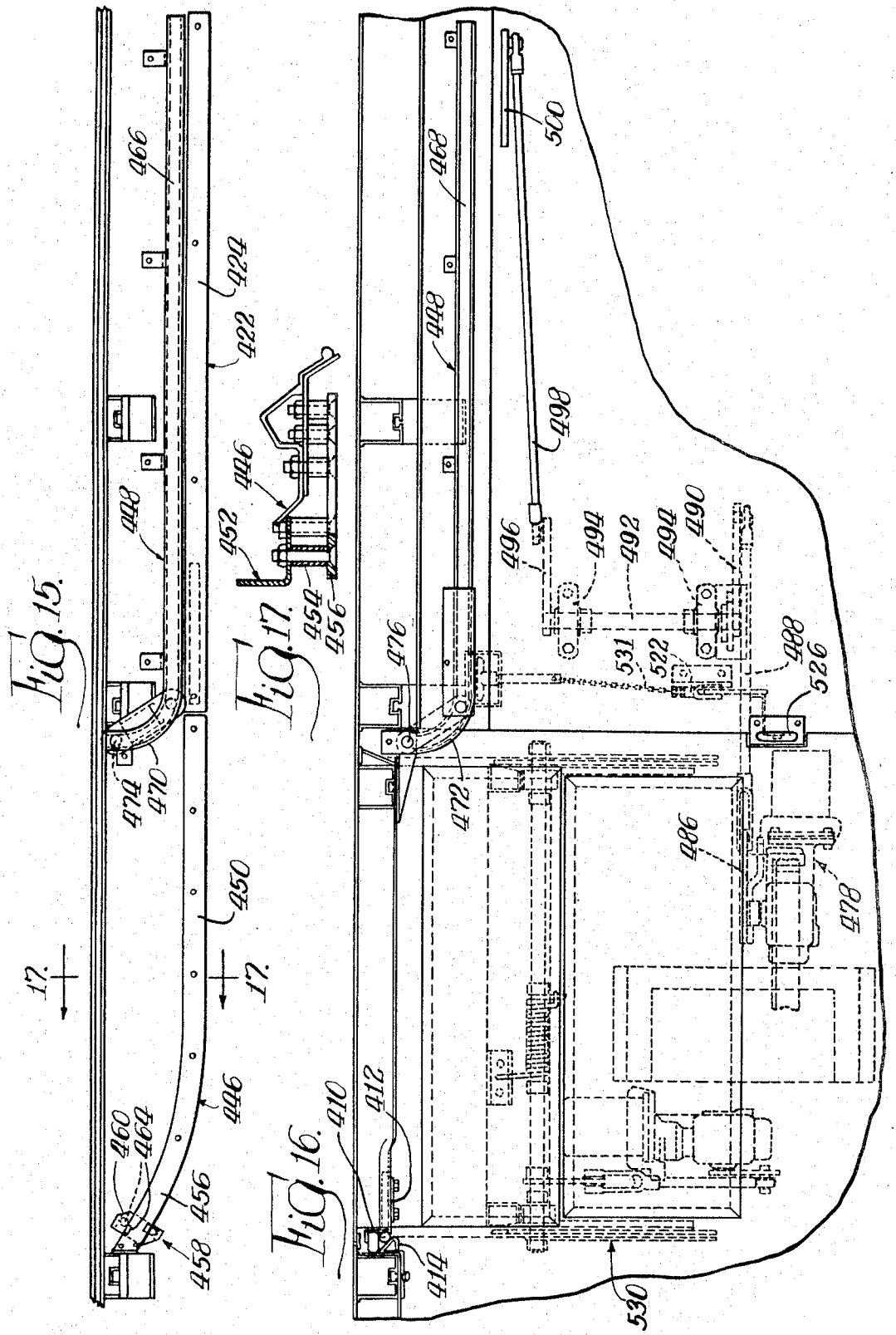


Fig. 13.

July 8, 1969 K. DAUGIRDAS 3,453,778

PLUG DOOR MECHANISM

Filed April 20, 1967 Sheet 8 of 8



United States Patent Office 3,453,778
Patented July 8, 1969

3,453,778

PLUG DOOR MECHANISM

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Int. Cl. E05d 15/10
U.S. Cl. 49—214 10 Claims

ABSTRACT OF THE DISCLOSURE

Guide and actuating mechanism for effecting compound lateral and longitudinal movement of a plug door into and out of a door frame.

Vehicles such as passenger trains require doors in the side walls thereof for passenger transfer. Swinging doors are disadvantageous because they obstruct the passageway when open, and have in general been displaced by sliding doors. However, conventional sliding doors, which either are outside hung projecting beyond the perimeter of the car or are recessed to slide into the car frame, have proved unsatisfactory for use in high-speed passenger trains. They are difficult to seal along the top and bottom edges; they are attended by undesirable air pockets, and present a poor aesthetic appearance, because the outer faces thereof do not lie flush with the outer surface of the vehicle side wall.

It is a principal object of my present invention to provide, for use in a vehicle such as a railway passenger car, a side door having the advantages, but not the disadvantages, of a sliding door. Among other objects of my present invention are to provide a door that is opened and closed through compound movement laterally and longitudinally of the car wall, that is effectively sealed along all four edges when closed, that is flush with the outer surface of the car wall when closed, that is positively locked in closed position, that is properly supported and guided without obstructing the passageway, that is arranged to be opened positively under adverse conditions such as icing, and that can be matched to straight or contoured side walls.

Now in order to acquaint those skilled in the art with the manner of constructing and using door operating mechanisms in accordance with the principles of my present invention, I shall describe in connection with the accompanying drawing preferred embodiments of my invention.

In the drawings:

FIGURE 1 is a schematic view of a vehicle, such as a railway passenger car, with which my present invention may be incorporated;

FIGURE 2 is an enlarged fragmentary diagrammatical view showing in plan a plug door in closed position and the actuating means therefor of my present invention;

FIGURE 3 is a fragmentary view corresponding generally to FIGURE 2, but showing the plug door in full open position;

FIGURE 4 is a fragmentary elevational view of the inside of the plug door and actuating means of FIGURE 2;

FIGURE 5 is a further enlarged sectional view, taken substantially along the line 5—5 of FIGURE 4, looking in the direction indicated by the arrows;

FIGURE 6 is a fragmentary elevational diagrammatical view of the inside of a modified embodiment of plug door and actuating means therefor of my present invention;

FIGURE 7 is a fragmentary view showing in plan the plug door and actuating means of FIGURE 6;

FIGURE 8 is a sectional view, taken substantially along the line 8—8 in FIGURE 6, looking in the direction indicated by the arrows;

FIGURE 9 is an enlarged sectional view taken substantially along the line 9—9 in FIGURE 6, looking in the direction indicated by the arrows;

FIGURE 10 is a fragmentary elevational diagrammatical view of the inside of another modified embodiment of plug door and actuating means therefor of my present invention;

FIGURE 11 is a fragmentary view showing in plan the plug door and actuating means of FIGURE 10;

FIGURE 12 is a fragmentary elevational diagrammatical view of the inside of a further modified embodiment of plug door and actuating means therefor of my present invention;

FIGURE 13 is a sectional view, taken substantially along the line 13—13 in FIGURE 12, looking in the direction indicated by the arrows;

FIGURE 14 is a sectional view, taken substantially along the line 14—14 in FIGURE 12, looking in the direction indicated by the arrows;

FIGURE 15 is a sectional view, taken substantially along the line 15—15 in FIGURE 12, looking in the direction indicated by the arrows;

FIGURE 16 is a sectional view, taken substantially along the line 16—16 in FIGURE 12, looking in the direction indicated by the arrows; and

FIGURE 17 is a sectional view, taken substantially along the line 17—17 in FIGURE 15, looking in the direction indicated by the arrows.

Referring now to FIGURE1, there is shown schematically and indicated generally by the reference numeral 20 the body of a vehicle such as a railway passenger car. The vehicle body 20 includes side walls 22 having associated therewith a plurality of plug doors 24. Since the several plug doors 24, and the actuating means of my present invention for each door, are of the same construction and operation, except for a reversal in the position or arrangement of parts as will be understood by those skilled in the art, only one plug door 24 and the actuating means therefor will be described in detail herein.

As shown in FIGURE 4, the vehicle side will 22 is provided with a door frame 26 having first and second side margins 28 and 30 and upper and lower margins 32 and 34. The plug door 24 has leading and trailing side edges 36 and 38 and upper and lower edges 40 and 42 which are respectively adapted for mating relation with the door frame margins 28, 30, 32 and 34. My present invention is especially concerned with actuating means suitable for effecting compound movement of the plug door 24 laterally and longitudinally of the side wall 22.

The door actuating means includes an upright generally rectangular sliding frame 44 which is movable rectilinearly in a path lengthwise of the wall 22 within a pocket inside the car structure. The sliding frame 44 is supported and guided by first guide means 46 in the form of a hanger assembly. The first guide means 46 comparises a horizontal track member 48 mounted to the vehicle ceiling 50 by means of bracket members 52. The track member 48 extends away from the second side margin 30 of the door frame 26 lengthwise of the vehicle wall 22 as shown in FIGURES 2 and 4. Mounted for sliding movement in the track member 48 is a carriage assembly 54 (FIGURE 5) which includes ball bearings 56 arranged in a retainer 58, and a depending center track 60 which is secured to and supports the sliding frame 44 as shown in FIGURE 4.

The sliding frame 44 is interconnected with the plug door 24 by linkage means indicated generally at 62. The linkage means 62 comprises upper and lower horizontal links 64 and 66 which are pivotally mounted on vertical axes on the upper and lower ends of a shaft 68 mounted

along one side of the sliding frame 44. The other ends of the links 64 and 66 are pivotally mounted on spindles 70 and 72 carried by brackets 74 and 76 secured to the inboard side of the plug door 24 adjacent the trailing and upper and lower edges thereof.

Both the leading and trailing edges 36 and 38 of the plug door 24 are suitably guided during movement of the door into and out of the door frame 26. Second guide means 78, associated with the leading edge of the plug door 24 as shown in FIGURES 2 and 4, comprises a horizontal cylindrical guide member 80 extending across the door frame and secured at its ends in brackets 82 and 84 (FIGURE 4) suspended from the vehicle ceiling 50. The guide member 80 has an end section 86 inclined inwardly toward the door frame 26 adjacent the first side margin 28 thereof as shown in FIGURE 2. Mounted on the plug door 24 adjacent the leading and upper edges thereof is a bracket 88 (FIGURE 4) which pivotally supports on a vertical axis carriage means 90 in the form of a carrier member 92 rotatably supporting a pair of rollers engageable with the upper and lower surfaces of the guide member 80. In the foregoing construction, part of the weight of the plug door 24 is supported by the upper link 64 carried by the sliding frame 44, while the remaining part of the door weight is supported by the second guide means 78.

Third guide means 94, associated with the trailing edge 38 of the plug door 24, comprises horizontal upper and lower guide channels 96 and 98 mounted respectively to the vehicle ceiling 50 and the vehicle floor 100. The guide channels 96 and 98 extend away from the second side margin 30 of the door frame 26 adjacent the upper and lower margins thereof and lengthwise of the vehicle wall 22. The guide channels 96 and 98 have end sections 102 and 104 curved inwardly toward the door frame 26 adjacent the second side margin 30 thereof. Roller members 106 and 108 are respectively rotatably mounted at the ends of the spindles 70 and 72 and are guided in the guide channels 96 and 98. Also, the lower end of the shaft 68 is provided with a roller 109 which rides in the guide channel 98 for guiding the lower part of the sliding frame 44.

A suitable flexible seal strip 110 is arranged about the margins of the door frame 26. To insure that the leading edge 36 of the plug door 24 has proper sealing engagement with the seal strip 110 when the door is in closed position, wedge or cam means may be provided at the top and/or bottom of the leading edge of the plug door. For example, as shown in FIGURE 4, a roller 112 may be rotatably mounted about a vertical axis on a bracket 114 secured to the vehicle side wall 22, and a cooperating cam plate 116 may be secured to the adjacent corner of the plug door 24. When the door is in closed position, the outer face thereof lies flush with the outer surface of the vehicle side wall for complete streamlining.

The power actuated means for moving the sliding frame 44 whereby to effect compound lateral and longitudinal movement of the plug door 24 into and out of the door frame 26 is comprised of a drive motor assembly 118 mounted immediately above the door frame 26 on the vehicle ceiling 50. The drive motor assembly 118 includes an electric motor 120 and a gear box 122 having an output shaft 124. Means for transmitting force between the output shaft 124 and the sliding frame 44 comprises a crank arm 126 secured to the output shaft 124 for revolving movement about a horizontal axis. A connecting rod 128 is pivotally secured at one end to the free end of the crank arm 126 and extends lengthwise of the vehicle side wall 22. The other end of the connecting rod 128 is pivotaly secured to a lever 130 affixed to a horizontal shaft 132 journalled in bearing blocks 134 secured to the vehicle ceiling 50. Also affixed to the shaft 132 is the one end of a downwardly extending lever 136. The other end of the lever 136 is slidably connected to the sliding frame 44 by means of a roller 138 which has rolling engagement with a vertical channel 140 secured to the adjacent side of the frame 44. The lever 130, shaft 132 and lever 136 define lever means between connecting rod 128 and the channel 40.

I shall now describe the manner in which the plug door 24 is opened and closed. To open the door, the drive motor 120 is energized to revolve the crank arm 126 counterclockwise from the position shown in FIGURE 4. As a result, the connecting rod 128 is drawn to the left, the interconnected levers 130 and 136 are pivoted counterclockwise, and the roller 138 riding in the channel 140 draws the latter and the sliding frame 44 to the right. As the sliding frame 44 moves to the right, it acts through the upper and lower links 64 and 66 to withdraw the plug door 24 from the door frame 26. By reason of the geometry of the several guide means, the opening force transmitted to the plug door 24 by the links 64 and 66 has both lateral and longitudinal components, compound lateral and longitudinal movement of the plug door is effected, and the seals along the edges of the door are broken in successive steps. First, the seal along the trailing edge 38 of the door is broken; then, the seals along the upper and lower edges 40 and 42; and last, the seal along the leading edge 36. The opening force operating initially on the plug door is at its maximum value because the crank arm 126 and connecting rod 128 are close to an over-center position. Because the seals along the door edges are broken in successive steps, rather than simultaneously, more positive opening of the door is insured under adverse conditions, for example, due to icing. During opening of the plug door 24, the door is moved from the closed position shown in full lines in FIGURES 2 and 4, through the intermediate open position shown in dotted lines in FIGURE 2, and finally to the full open position shown in solid lines in FIGURE 3. When the door is fully open, the motor 120 is deenergized.

To close the plug door 24, the drive motor 120 is energized to revolve the crank arm 126 clockwise to the position shown in FIGURE 4. At this time, the connecting rod 128 is moved to the right, the interconnected levers 130 and 136 are pivoted clockwise, and the sliding frame 44 is returned to the solid line position shown in FIGURE 4. As the plug door 24 approaches the door frame 26, the longitudinal force component acting on the door forces the cam plate 116 behind the roller 112 whereby the leading edge 36 of the door is urged laterally into sealing engagement with the adjacent seal strip. Also, the lateral force component acting on the door 24 forces the trailing edge 38 of the door, and the upper and lower edges 40 and 42 thereof, into sealing engagement with the adjacent seal strips along the door frame. In the final stage of door closing, the pivotal connection of the crank arm 126 and connecting rod 128 is moved downwardly over-center (FIGURE 14), the drive motor 120 is deenergized, and the door actuating means thereafter serves to lock the plug door 24 in a closed position. Again, by reason of the geometry of the several guide means, closing of the door is effected through compound lateral and longitudinal movement thereof. The closing force, which is transmitted from the sliding frame 44 to the plug door 24 by the links 64 and 66, may be regulated by preloading, or applying spring means to, one of the members of the door actuating linkage means. In emergencies, a camming unit 142, which is provided in the vehicle ceiling 50 may be manually actuated for moving the pivotal connection of the crank arm 126 and connecting rod 128 upwardly over-center to unlock the plug door.

Referring now to FIGURES 6–9, I shall describe a modified embodiment of my present invention. The vehicle side wall 22*a* and the plug door 24*a*, except for the curvature or contour thereof as illustrated in FIGURE 9, are similar to the side wall 22 and the plug door 24 shown in FIGURES 1–4. The vehicle side wall 22*a* is provided with a door frame 150 having first and second side margins 152 and 154 and upper and lower margins 156 and 158. The plug door 24*a* has leading and trailing

recessed side edges 160 and 162 and upper and lower recessed edges 164 and 166 which are respectively adapted for mating relation with the door frame margins 152, 154, and 156 and 158. A seal strip 168 is arranged about the margins of the door frame 150, and a resilient strip 170 is mounted along the leading side edge 160 of the door 24*a*.

The means for effecting compound movement of the plug door 24*a* laterally and longitudinally of the side wall 22*a* includes a sliding frame 172 having interconnected upper and lower sections 174 and 176 inclined inwardly at their upper and lower ends to accommodate the curvature of the wall 22*a* and door 24*a*. The sliding frame 172 is supported and guided for movement rectilinearly in a path lengthwise of the wall 22*a* by first guide means 178 in the form of a conventional hanger assembly such as shown in FIGURE 5. The first guide means 178 comprises a horizontal track member 180 suitably mounted to the vehicle ceiling, and a carriage assembly slidably mounted therein with a depending center track 184 which is secured to and supports the sliding frame 172 as shown in FIGURE 6.

Linkage means 186 serves to interconnect the sliding frame 172 with the plug door 24*a*. The linkage means 186 includes upper and lower hinge links 188 and 190 which at their one ends are pivotally mounted in brackets 192 and 194 secured to the sliding frame 172, and at their other ends are pivotally mounted on spindles 196 and 198 carried by brackets 200 and 202 secured to the plug door 24*a*.

Second guide means 204, as shown in FIGURES 6 and 7, comprises a horizontal cylindrical guide member 206 which is secured at its ends in brackets 208 and 210, suspended from the vehicle ceiling. As shown in FIGURE 7, the guide member 206 has an end section 212 inclined inwardly toward the door frame 150 adjacent the first side margin 152 thereof. Mounted on the plug door 24*a* is a bracket 214 which pivotally supports carriage means 216 in the form of a carrier member 218 rotatably supporting a pair of rollers engageable with the upper and lower surfaces of the guide members 206.

Third guide means 220 comprises horizontal upper and lower guide channels 222 and 224 mounted respectively to the vehicle ceiling and the vehicle floor. The guide channels 222 and 224 have end sections 226 and 228 curved inwardly toward the door frame 150. Guided in the guide channels 222 and 224 are roller members 230 and 232 which are respectively rotatably mounted at the ends of the spindles 196 and 198. Rollers 234, which are rotatably suspended from the bracket 194 at the lower end of the sliding frame 172, also ride in the guide channel 224 for guiding the lower part of the sliding frame 172.

Power actuated means for moving the sliding frame 172 and, in turn, the plug door 24*a*, comprises a drive motor assembly 236 mounted, intermediate of the planes of the upper and lower margins of the door frame 150, on a bed plate 238 secured to an inner partition wall 240 as shown in FIGURE 9. The drive motor assembly 236 includes an electric motor 242 and a gear box 244 having an output shaft 246. A crank arm 248 at one end is secured to the output shaft 246 and at the other end has a sliding connection with the sliding frame 172 through a roller 250 which has rolling engagement with a vertical channel 252 secured to the adjacent side of the upper section 174 of the frame 172. During energization of the motor 242, the crank arm 248 is revolvable about the axis of the output shaft 246, and serves as force transmitting means between the output shaft 246 and the sliding frame 172. To effect proper sealing engagement between the leading edge 160 of the plug door 24*a* and the seal strip 168 when the door is in closed position, wedge or cam means may be provided at the top and bottom of the leading edge of the plug door. Thus, as shown in FIGURE 6 rollers 254 may be rotatably mounted on brackets 256 secured to the vehicle side wall 22*a* and cooperating cam plates 258 may be secured to the adjacent corners of the plug door 24*a*.

When the motor 242 is energized and the crank arm 248 is revolved clockwise from the position shown in solid lines in FIGURE 6, to the position shown in dotted lines, the sliding frame 172 is moved to the right and the door 24*a* is withwrawn from the door frame 150 to a full open position. When the motor 242 is energized and the crank arm 248 is revolved counterclockwise from the position shown in dotted lines back to the position shown in solid lines, the sliding frame 172 is returned to the left and the door 24*a* is disposed in a closed position. The several guide means shown in FIGURES 6–9 function in the same manner as the corresponding guide means shown in FIGURES 2–4, and the door 24*a* is opened and closed in the same manner as the door 24. In the final stage of door closing, the crank arm 248 is moved downwardly over-center (FIGURE 6) to lock the door in a closed position. For emergency use, a cable 260 is trained over pulleys 262 and 264 and is connected at one end to a camming unit 266 that is engaged by the crank arm 248 when the latter is in door closing position. The other end of the cable 260 is provided with an operating knob 268 which may be pulled downwardly from the position shown in FIGURE 6 whereby to draw the bracket 266 upwardly to move the crank arm 248 upwardly over-center to unlock the plug door when required.

Another modified embodiment of my present invention is shown in FIGURES 10 and 11. The vehicle side wall 22*b* and the plug door 24*b*, except for the provision of a window 274 in the wall adjacent the door, are similar to the side wall 22 and plug door 24 of FIGURES 1–4. The vehicle side wall 22*b* has formed therein a door frame 276 with first and second side margins 278 and 280 and upper and lower margins 282 and 284. The plug door 24*b* has leading and trailing side edges 286 and 288 and upper and lower edges 290 and 292 which are respectively arranged for mating relation with the door frame margins 278, 280, 282, and 284.

Compound movement of the plug door 24*b* laterally and longitudinally of the side wall 22*b* is adapted to be effected by door actuating means which includes an upright, generally rectangular sliding frame 294. The frame 294 is movable rectilinearly in a path lengthwise of the wall 22*b*, and has a height approximately one-half that of the door 24*b* so that it may be mounted for sliding movement in the area immediately below the window 274. First guide means 295 includes a lower horizontal track member 296 secured to the vehicle floor and an upper horizontal guide channel 297 suitably mounted to the vehicle wall 22*b* intermediate of the top and bottom thereof below the window 274. The lower end of the sliding frame 294 is provided with a carriage assembly 298, which may be in the form shown in FIGURE 5, engageable in and along the track member 296 for guiding and supporting the sliding frame 294. Mounted for sliding movement in the guide channel 297 is a carriage assembly 300 which includes rollers 302 rotatably mounted on shafts 304 secured to a bracket 305 carried by the sliding frame 294. The sliding frame 294 and the plug door 24*b* are interconnected by linkage means indicated generally at 306. The linkage means 306 comprises an upper horizontally extending hinge link 308 pivotally mounted at one end on the lower end of the shaft 304, and a lower horizontally extending hinge link 310 pivotally mounted at one end in a bracket 312 secured to the sliding frame 294. The other ends of the hinge links 308 and 310 are pivotally mounted on spindles 314 and 316 respectively carried by brackets 318 and 320 secured to the plug door 24*b*.

The leading and trailing edges 286 and 288 of the plug door 24*b* are suitably guided during movement of the door into and out of the door frame 276 by means of second and third guide means 322 and 324. The second guide means 322 comprises a horizontal guide mem-

ber 326 which has an end section 328 inclined inwardly toward the door frame 276, and which, at its ends, is secured in brackets 330 and 332 suspended from the vehicle ceiling. Secured to the plug door 24*b* adjacent the leading and upper edges thereof is a bracket 334 which pivotally supports carriage means 336 in the form of a carrier member 338 rotatably supporting a pair of rollers engageable with the upper and lower surfaces of the guide member 326.

The third guide means 324 comprises horizontal upper and lower guide channels 340 and 342 mounted respectively to the vehicle ceiling and the vehicle floor. The guide channels 340 and 342 extend lengthwise of the vehicle wall 22*b* and respectively have end sections 344 and 346 curved inwardly toward the door frame 276. A roller member 348 is rotatably mounted at the upper end of a spindle 350 carried in a bracket 352 secured to the door 24*b*, while a roller member 354 is rotatably mounted at the end of the lower spindle 316. The roller members 348 and 354 are respectively guided in the guide channels 340 and 342.

Arranged about the margins of the door frame 276 is a flexible seal strip 358. Proper sealing engagement of the leading edge of the plug door 24*b* with the seal strip 358 may be attained by providing wedge or cam means at the bottom of the leading edge of the plug door. Such means may comprise a roller 360 rotatably mounted about a vertical axis on a bracket 362 secured to the plug door 24*b*, and a cooperating cam plate 364 secured to the adjacent corner of the door frame 276. As will be appreciated, similar wedge or cam means may be provided at the top of the leading edge of the plug door 24*b* if required.

Compound lateral and longitudinal movement of the plug door 24*b* into and out of the door frame 276 is effected by movement of the sliding frame 294 lengthwise of the vehicle wall 22*b*. Movement of the sliding frame 294 is adapted to be selectively effected by power actuated means comprising a drive motor assembly 366 mounted on the vehicle floor. The drive motor assembly 366 is comprised of an electric motor 368 and a gear box 370 having an output shaft 372. Extending between the output shaft 372 and the sliding frame 294 is force transmitting means comprising a crank arm 374 secured to the output shaft 372 for revolving movement about a horizontal axis. A connecting rod 376 is pivotally secured at its one end to the free end of the crank arm 374 and at its other end to a lever 378 intermediate of the ends thereof. One end of the lever 378 is pivotally mounted in a bearing block 380 secured to the vehicle floor, and the other end thereof is slidably connected to the sliding frame 294 by means of a roller 382 which has rolling engagement with a vertical channel 384 secured to the adjacent side of the frame 294.

To fully open the plug door 24*b*, the sliding frame 294 is moved from the position shown in solid lines in FIGURE 10 to the right to the position shown in dotted lines. Such movement of the sliding frame 294 is effected by energizing the motor 368 and revolving the crank arm 374 clockwise. The connecting rod 376 is thereby pulled to the right and the lever 378 is pivoted clockwise. To close the plug door 24*b*, the motor 368 is energized for revolving the crank arm 374 counterclockwise back to the position shown in FIGURE 10, whereupon the connecting rod 376, lever 378 and sliding frame 294 are returned to the positions shown in solid lines. The several guide means shown in FIGURES 10 and 11, except as otherwise indicated, function in the same manner as the corresponding guide means shown in FIGURES 2–4, and the door 24*b* is opened and closed in the same manner as the door 24. At the final stage of door closing, the crank arm 374 is moved downwardly over-center (FIGURE 10) to lock the door in a closed position. To permit the crank arm 374 to be moved upwardly over-center to unlock the door in an emergency situation, a bracket 386 is arranged beneath the pivotal connection between the crank arm 374 and the connecting rod 376. Suitable manually operated rod or cable means (not shown) are connected to the bracket 386 to permit upward actuation thereof as may be required.

Referring now to FIGURES 12–17, there is shown a further modified embodiment of my present invention. The vehicle side wall 22*c* and the plug door 24*c* are similar to the wall 22*a* and door 24*a* of FIGURES 6–9. Formed in the vehicle side wall 22*c* is a door frame 392 having first and second side margins 394 and 396 and upper and lower margins 398 and 400. The plug door 24*c* has leading and trailing side edges 402 and 404 and upper and lower edges 406 and 408 respectively oriented for mating relation with the door frame margins 394, 396, 398 and 400. A suitable flexible seal strip is provided about the margins of the door frame 392, and wedge or cam means (FIGURES 12 and 16) is provided at the bottom of the leading edge of the plug door to insure proper sealing engagement between the leading edge and the seal strip. More particularly, a roller 410 is rotatably mounted on a bracket 412 secured to the door 24*c*, and a cam plate 414, which is arranged to be engaged by the roller 410, is secured to the adjacent portion of the door frame 392.

An upright generally rectangular sliding frame 416, which is movable rectilinearly in a path lengthwise of the wall 24*c*, is comprised of interconnected upper and lower sections 418 and 420 inclined inwardly at their opposed ends to accommodate the curvature of the wall 22*c* and door 24*c*. First guide means 422 in the form of a hanger assembly which serves to support and guide the sliding frame 416, is comprised of a horizontal track member 424 suspended from the vehicle ceiling. Mounted for sliding movement in the track member 424 is a roller carriage assembly 426 of the type shown in FIGURE 5 having a depending center track 427 secured to and supporting the sliding frame 416.

To interconnect the sliding frame 416 with the plug door 24*c*, linkage means is provided at 428. The linkage means 428 is comprised of upper and lower horizontally disposed hinge links 430 and 432 which at their one ends are pivotally mounted to brackets 434 and 436 secured to the sliding frame 416 and at their other ends are pivotally mounted on spindles 438 and 440 carried by brackets 442 and 444 secured to the plug door 24*c*.

To guide the plug door 24*c* during opening and closing movement thereof, second and third guide means 446 and 448 are provided. The second guide means 446 includes a horizontal guide member 450 suspended from the vehicle ceiling by bracket means 452 and lengthwise spaced post members 454 as shown in FIGURES 12, 15 and 17. The guide member 450 has an end section 456 (FIGURE 15) inclined inwardly toward the door frame 392, and has associated therewith carriage means 458. The carriage means 458 (FIGURES 12 and 15) includes a carrier member 460 which is pivotally supported on a vertical axis in a bracket member 462 secured to the plug door 24*c* and which rotatably supports a plurality of rollers 464 engageable with the upper and edge surfaces of the guide member 450. The third guide means 448 (FIGURES 15 and 16) is comprised of horizontal upper and lower guide channels 466 and 468 mounted respectively to the vehicle ceiling and vehicle wall. The guide channels 466 and 468 have end sections 470 and 472 curved inwardly toward the door frame 392. Roller members 474 and 476 (FIGURES 12, 15 and 16) are respectively mounted at the ends of the spindles 438 and 440 and are guided in the guide channels 466 and 468 respectively.

Longitudinal movement of the sliding frame 416, and, in turn, compound lateral and longitudinal movement of the plug door 24*c* into and out of the door frame 392, is adapted to be effected by power actuated means comprised of a drive motor assembly 478 mounted beneath the vehicle floor 479 and force transmitting linkage means arranged between the drive motor assembly and the sliding frame 416. More specifically, as shown in FIGURES 12 and 16, the drive motor assembly 478 includes an electric motor 480 and a gear 482 having an output shaft 484. A crank arm 486 is secured to the output shaft 484

and is revolvable therewith about a horizontal axis. A first conecting rod **488** is pivotally conencted at one end to the free end of the crank arm **486** and at the other end to the one end of a lever **490** which at its other end is affixed to a shaft **492**. The shaft **492** is journalled in bearing blocks **494** and has affixed thereto the one end of a lever **496**. The lever **490**, shaft **492** and lever **496** define first lever means. The other end of the lever **496** is pivotally connected to a second connecting rod **408** extending to and having pivotal connection with the one end of a lever **500**. The other end of the lever **500** (FIGURE 14) is secured to a shaft **502** which is rotatably mounted in a support member **504** and which also has affixed thereto the one end of a lever **506**. The lever **500**, shaft **502** and lever **506** serve to define second lever means. The other end of the lever **506** is pivotally connected to the one end of a third conecting rod **508** (FIGURE 12) which extends to and is pivotally connected at its other end to the one arm **510** of a bell crank **512**. The bell crank **512** is pivotally mounted on a horizontal shaft **514** suitably secured in the vehicle body wall. The other arm **516** of the bell crank **512** is provided at its outer end with a roller **518** which has rolling engagement in a vertical channel **520** secured to the sliding frame **416**.

When the motor **480** is energized and crank arm **486** is revolved counterclockwise from the position shown in FIGURE 12, the first and second connecting rods **488** and **498** are drawn to the left, the first lever means is pivoted counterclockwise while the second lever means is pivoted clockwise, the third connecting rod **508** is drawn downwardly, and the bell crank **512** is pivoted clockwise. By reason of such movement of the linkage members, the sliding frame **416** is moved to the right to the position shown in dotted lines and the plug door **24***c* is withdrawn from the door frame **392** to a full open position. When the motor **480** is then energized and the crank arm **486** is revolved clockwise toward the position shown in FIGURE 12, the several linkage members are correspondingly returned to the positions shown in FIGURE 12 and the sliding frame **416** is returned to the left to dispose the door **24***c* in closed position. The several guide means shown in FIGURES 12–17 function substantially in the same manner as the corresponding guide means shown in FIGURES 2–4, and the door **24***c* is opened and closed in the same manner as the door **24**. To lock the door **24***c* in closed position, the pivotal connection between the crank arm **486** and the first connecting rod **488** is moved downwardly over-center. In case of emergency a camming device **522** (FIGURES 12 and 13) is provided. Connected to this device are an upwardly extending rod **524** having a hand grip **526** at the upper end thereof, and a laterally extending handle and chain assembly **531**. Either upward movement of the handle **526** manulaly operable from inside the car, or outward movement of the handle and chain assembly **531** manually operable from outside of the car, effects rotation of the camming device **522** in a counterclockwise direction (FIGURE 13). Upon such rotation of the camming device **522**, a switch **532** is first deactuated for denergizing the drive motor **480**, and then the connection between the crank arm **486** and the first connecting rod **488** is moved upwardly over-center to unlock the door.

As shown in FIGURES 12, 13 and 16, a folding step assembly **528** may be mounted in the vehicle wall immediately below the door frame **392**. The folding step assembly **528** is arranged to be either retracted inwardly of the car body to the position shown in solid lines in FIGURE 13 or extended outwardly of the car body to the position shown in dotted lines. In the retracted position, the step assembly **528** defines the lower door frame margin **400**. Suitable motor and linkage means indicated generally at **530** is provided for retracting and extending the folding step assembly **528**. It will be appreciated that the drive motor assembly **478** and the associated linkage means for the sliding frame **416** are arranged so as not to interfere with the proper location and operation of the folding step assembly and actuating means therefor.

In each of the embodiments of my invention described above, it will be appreciated that the plug door is opened and closed through compound movement laterally and longitudinally of the car wall. In this connection, the several guide means provide balanced support for the weight of the door without obstructing the passageway. Additionally, the lateral and longitudinal force components produced by the actuating means serve to insure effective seal of the door along all four edges when closed, and also act to break the seals along the door edges in successive steps to increase break-away capability required under adverse conditions such as icing. Furthermore, the over-center arrangement of the linkage means serves to positively lock the door in closed position. Also, as dictated by spatial considerations, the drive motor assembly of the door operating mechanism may be located above the door, at the side of the door, on the vehicle floor, or beneath the vehicle floor. Finally, the door actuating means may be used with straight or contoured doors which can be matched to the contour of the car body. Because the outer face of the door is adapted to be disposed flush with the outer perimeter of the car wall, complete streamlining is attained.

While I have shown and described what I believe to be preferred embodiments of my present invention, it will be understood by those skilled in the art that various rearrangements and modifications may be made therein without departing from the spirit and scope of my invention.

I claim:

1. For use in a vehicle body including a wall having a door frame with first and second side margins and upper and lower margins, the combination of a door having leading and trailing side edges and upper and lower edges respectively adapted for mating relation with the first and second side margins and the upper and lower margins of the door frame; a sliding frame exclusively movable rectilinearly in a path lengthwise of the wall entirely at one side of the door frame; first guide means for guiding movement of said sliding frame; second guide means for guiding movement of said leading edge of said door, said second means comprising a horizontal guide member mounted adjacent the plane of the upper margin of the door frame and extending across the door frame, said guide member adjacent the first side margin of the door frame having an end section inclined inwardly toward the door frame, and carriage means guided on said guide member and pivotally secured on a vertical axis to said door adjacent said leading and upper edges thereof; third guide means for guiding movement of said trailing edge of said door, said third guide means comprising horizontal upper and lower guide channels mounted along the vehicle wall adjacent the planes of the upper and lower margins of the door frame and extending away from the second side margin of the door frame, said guide channels adjacent the second side margin of the door frame having end sections curved inwardly toward the door frame, and roller members guided in said upper and lower guide channels and pivotally mounted on virtical axes to said door adjacent said trailing and upper and lower edges thereof; linkage means interconnecting said sliding frame and said trailing edge of said door, said linkage means comprising upper and lower horizontal links pivotally connected on vertical axes at their one ends to said sliding frame and at their other ends to said door adjacent said trailing and upper and lower edges thereof; and power actuated means for moving said sliding frame whereby to effect compound and longitudinal movement of said door interiorly of the body into and out of the door frame.

2. The combination of claim **1** wherein said first guide means comprises a horizontal track member mounted lengthwise of the vehicle wall adjacent the plane of the

upper margin of the door frame and extending away from the second side margin of the door frame, and a carriage assembly guided and supported in said track member and secured to said sliding frame; and including roller means guided in said lower guide channel and pivotally mounted on a vertical axis to said sliding door.

3. The combination of claim 1 wherein said power actuated means comprises a drive motor assembly having an output shaft, and force transmitting means interconnecting said output shaft and said sliding frame.

4. The combination of claim 3 wherein said force transmitting means includes an operating member that is movable over-center to lock said door in closed position.

5. The combination of claim 3 wherein said drive motor assembly is mounted immediately above the door frame; and wherein said force transmitting means comprises a crank arm secured to said output shaft and being revolvable about a horizontal axis, a connecting rod pivotally secured at one end to said crank arm and extending lengthwise of the vehicle wall, lever means pivotally connected at its one end to the other end of said connecting rod and slidably connected at its other end to said sliding frame, and said lever means being pivotally mounted intermediate of its ends about a fixed horizontal axis.

6. The combination of claim 3 wherein said drive motor assembly is mounted intermediate of the planes of the upper and lower margins of the door frame; and wherein said force transmitting means comprises a crank arm secured to said output shaft and being revolvable about a horizontal axis, and said crank arm at its free end having a sliding connection with said sliding frame.

7. The combination of claim 3 wherein the drive motor assembly is mounted adjacent the plane of the lower margin of the door frame; and wherein said force transmitting means comprises a crank arm secured to said output shaft and being revolvable about a horizontal axis, a lever connected at its one end to the vehicle body and slidably connected at its other end to said sliding frame, and a connecting rod pivotally connected at one end to the free end of said crank arm and pivotally connected at its other end to said lever intermediate of the ends thereof.

8. The combination of claim 3 wherein said drive motor assembly is mounted below the plane of the lower margin of the door frame.

9. The combination of claim 1 including cooperating cam means between said leading edge of said door and said vehicle wall to insure proper sealing of said leading edge when said door is in closed position.

10. The combination of claim 1 wherein said sliding frame includes a vertical channel; and wherein said power actuated means comprises a drive motor assembly having an output shaft, and force transmitting means interconnecting said output shaft and said sliding frame, with said latter means including a force transmitting member having a sliding connection with said channel.

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