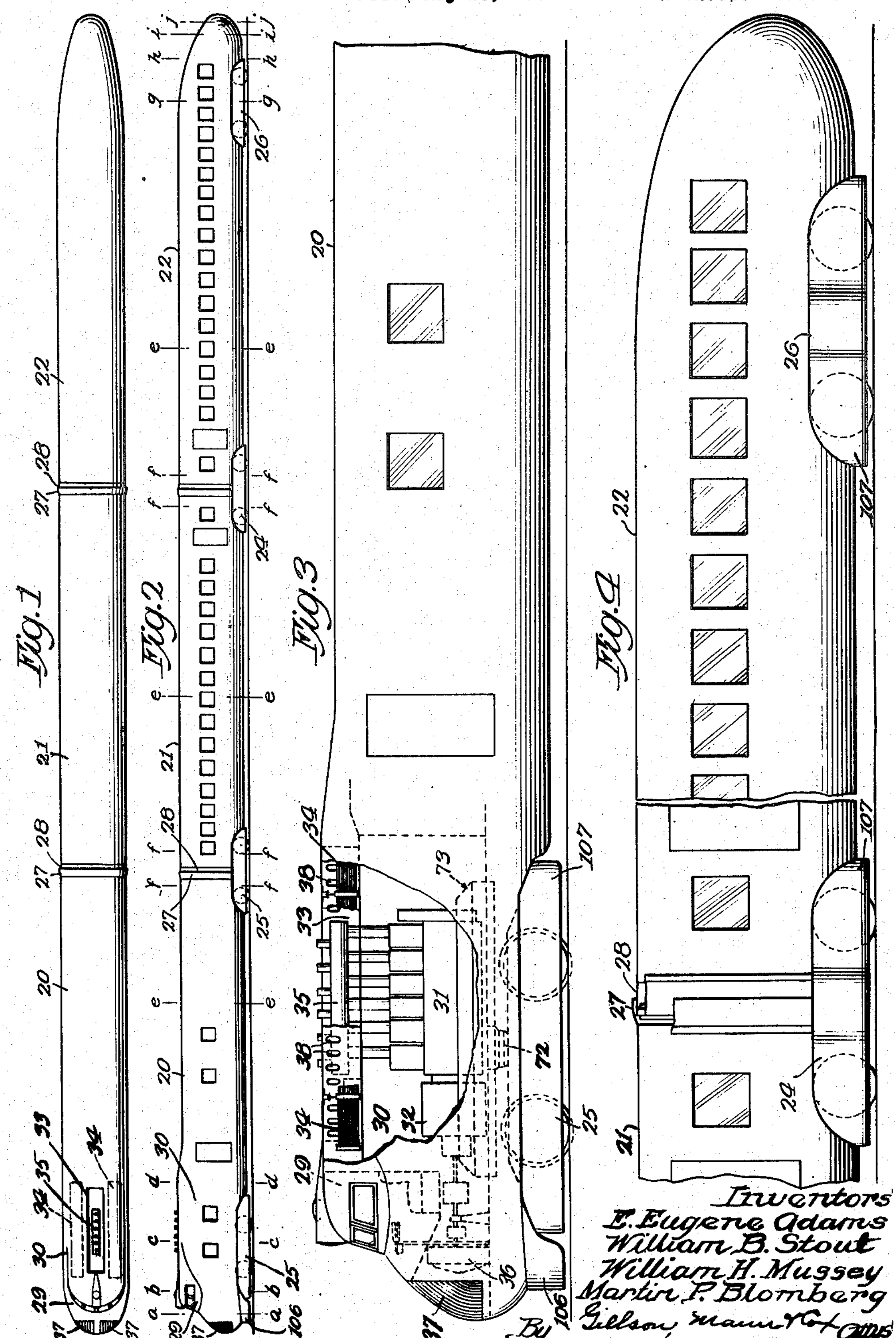
Sept. 21, 1937. E. E. ADAMS ET AL 2,093,535

RAIL CAR

Filed May 28, 1934 6 Sheets-Sheet 1



Inventors
E. Eugene Adams
William B. Stout
William H. Mussey
Martin P. Blomberg
By Gilson, Mann & Cox Attys

Sept. 21, 1937. E. E. ADAMS ET AL 2,093,535

RAIL CAR

Filed May 28, 1934 6 Sheets-Sheet 2

Fig. 6

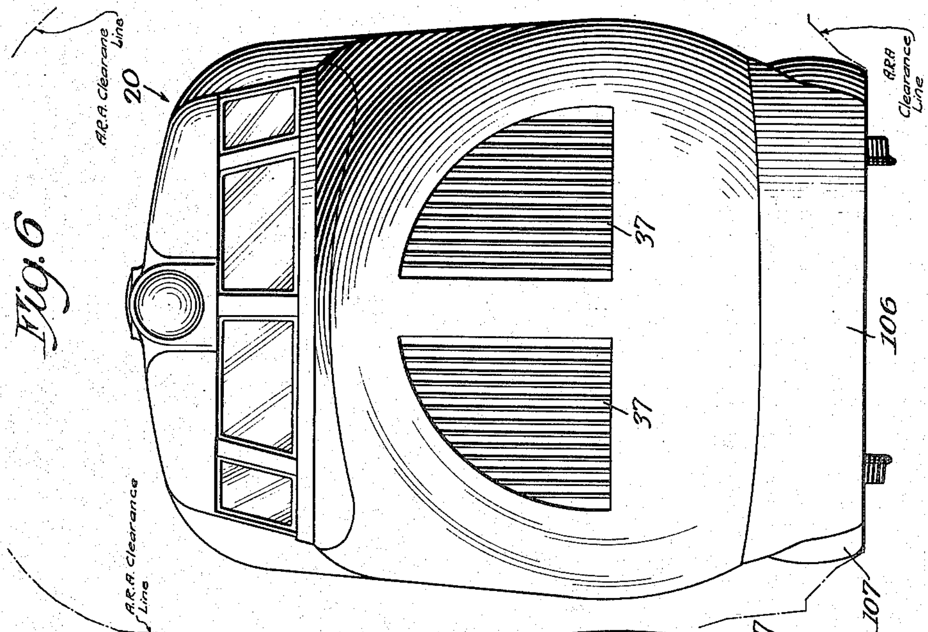
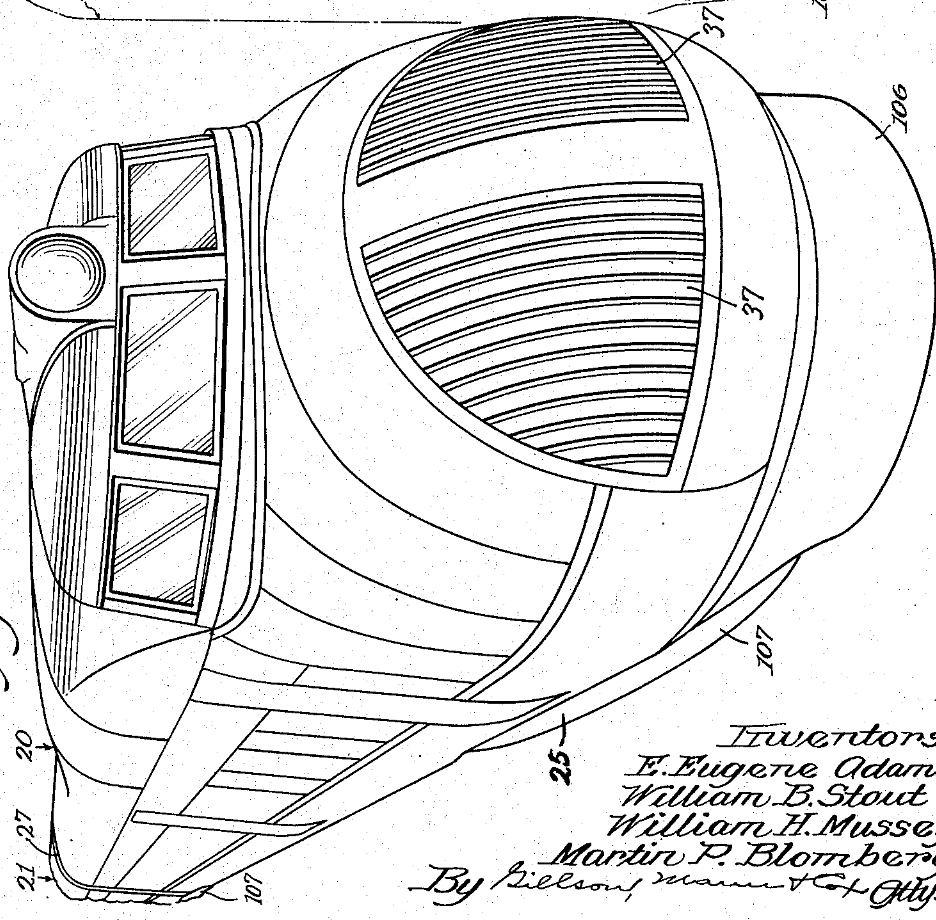


Fig. 5



Inventors
E. Eugene Adams
William B. Stout
William H. Mussey
Martin P. Blomberg
By Gillson, Mann & Cox Attys.

Sept. 21, 1937. E. E. ADAMS ET AL 2,093,535

RAIL CAR

Filed May 28, 1934 6 Sheets-Sheet 3

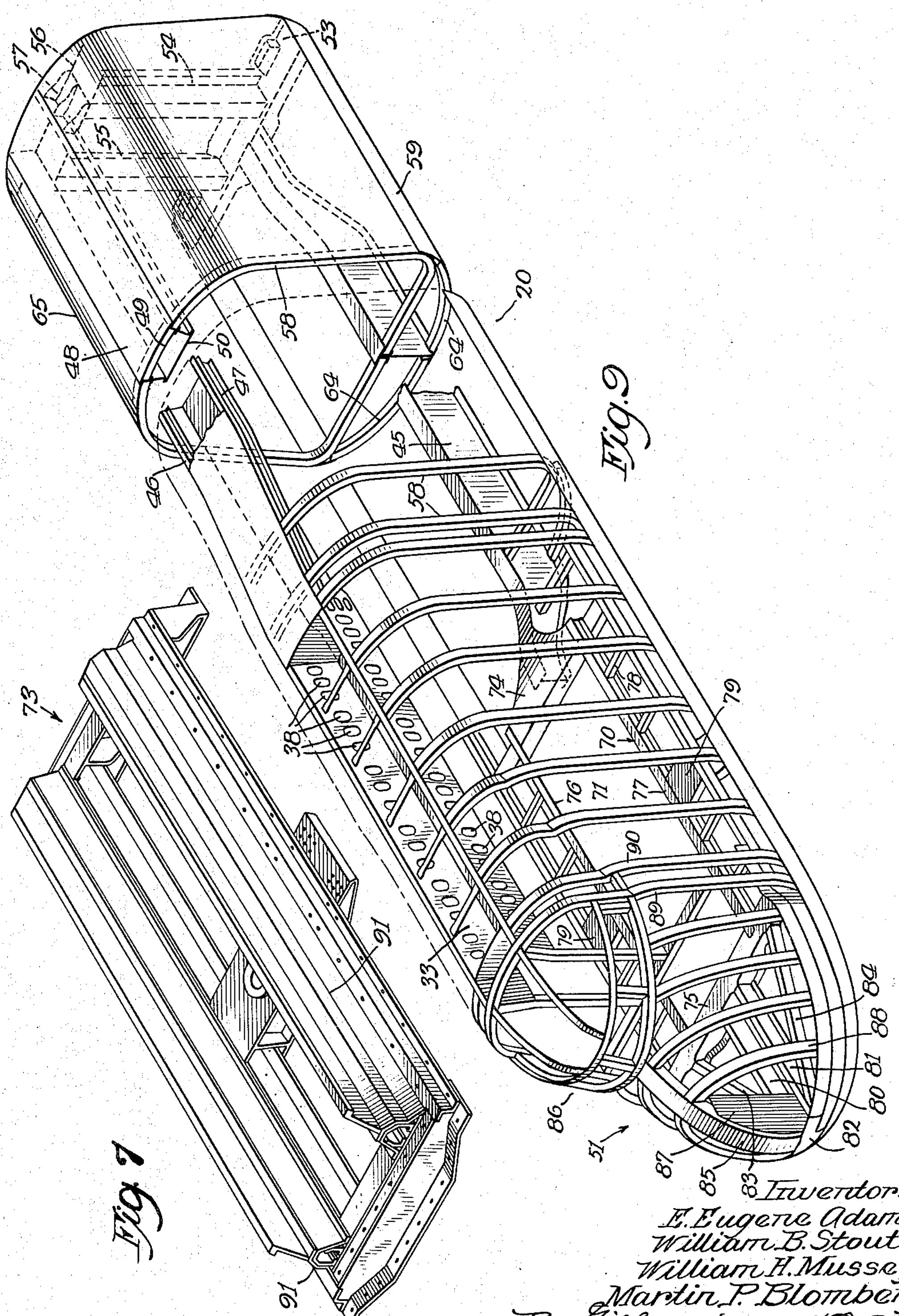


Fig. 9

Fig. 7

Inventors
E. Eugene Adams
William B. Stout
William H. Mussey
Martin P. Blomberg
By Gillson, Mann & Cox Attys

RAIL CAR

Filed May 28, 1934 6 Sheets-Sheet 4

Fig. 8a

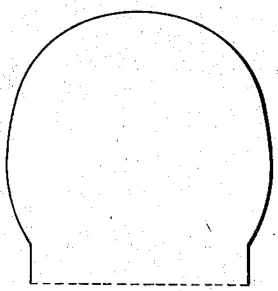


Fig. 8b

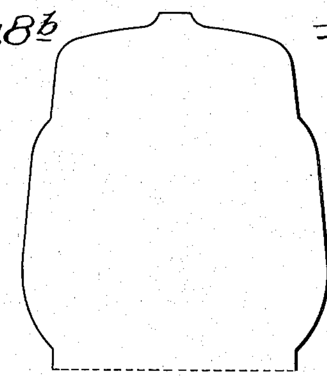


Fig. 8c

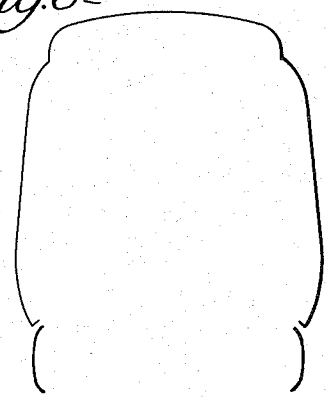


Fig. 8d

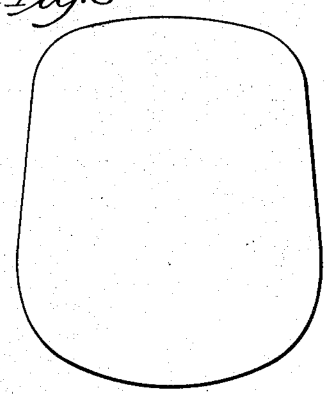


Fig. 8e

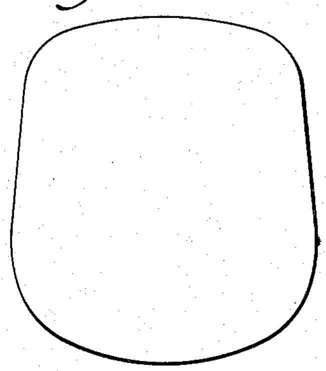


Fig. 8f

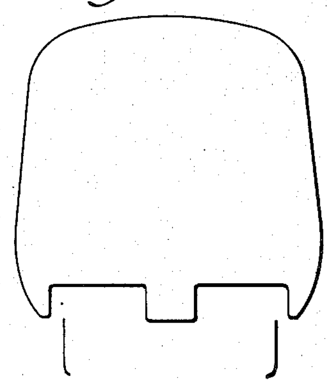


Fig. 8g

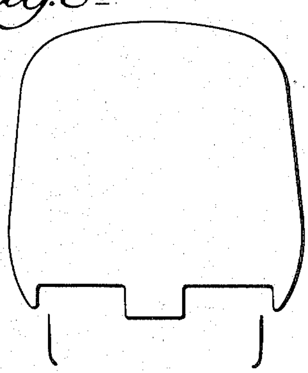


Fig. 8h

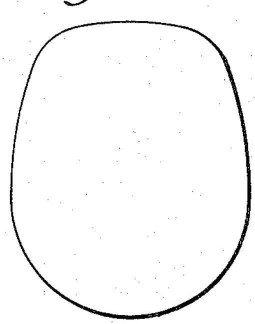


Fig. 8i

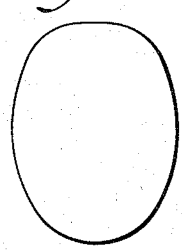
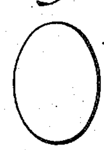


Fig. 8j



Inventors
E. Eugene Adams
William B. Stout
William H. Mussey
Martin P. Blomberg
By Gillson, Mann & Cox Attys

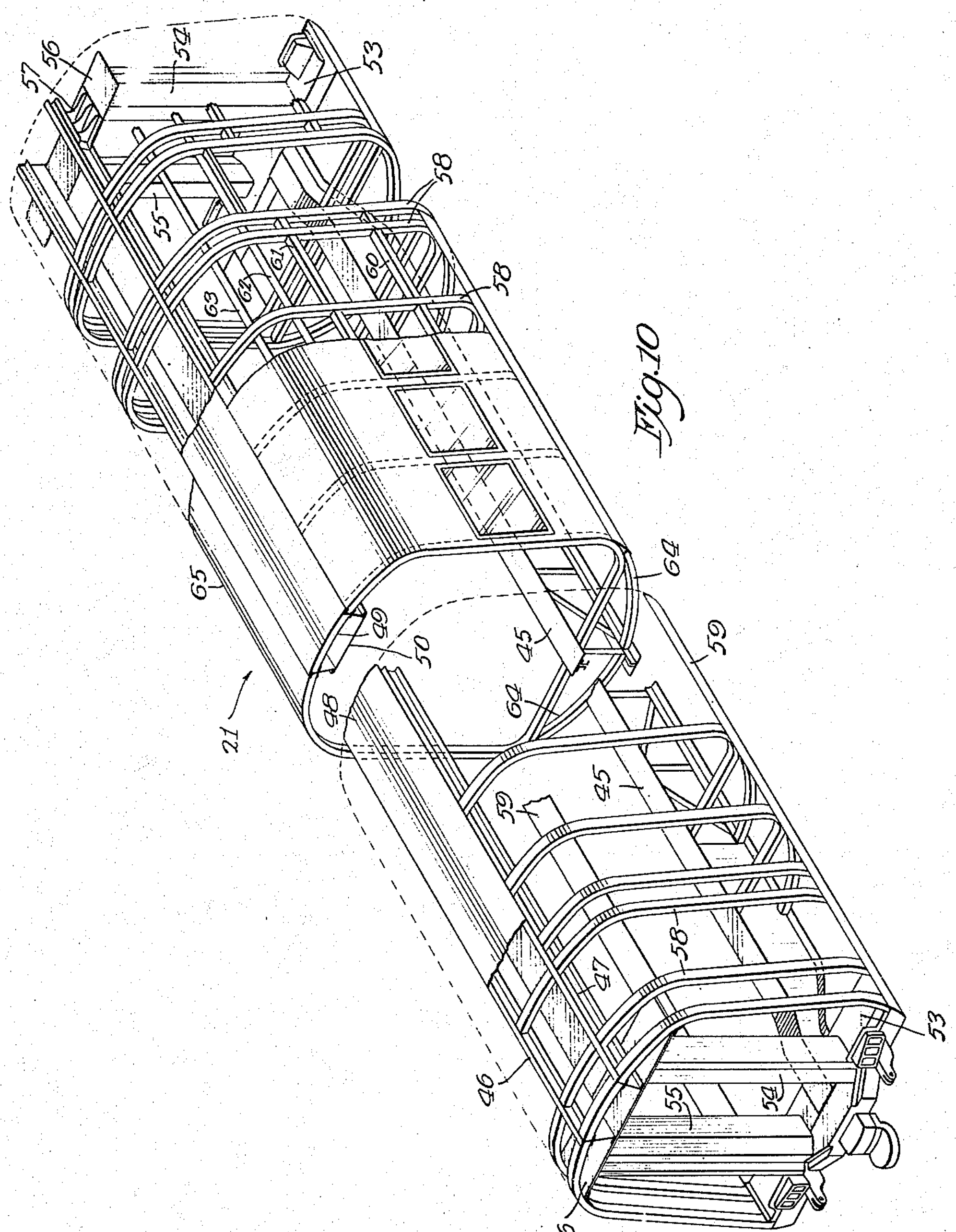


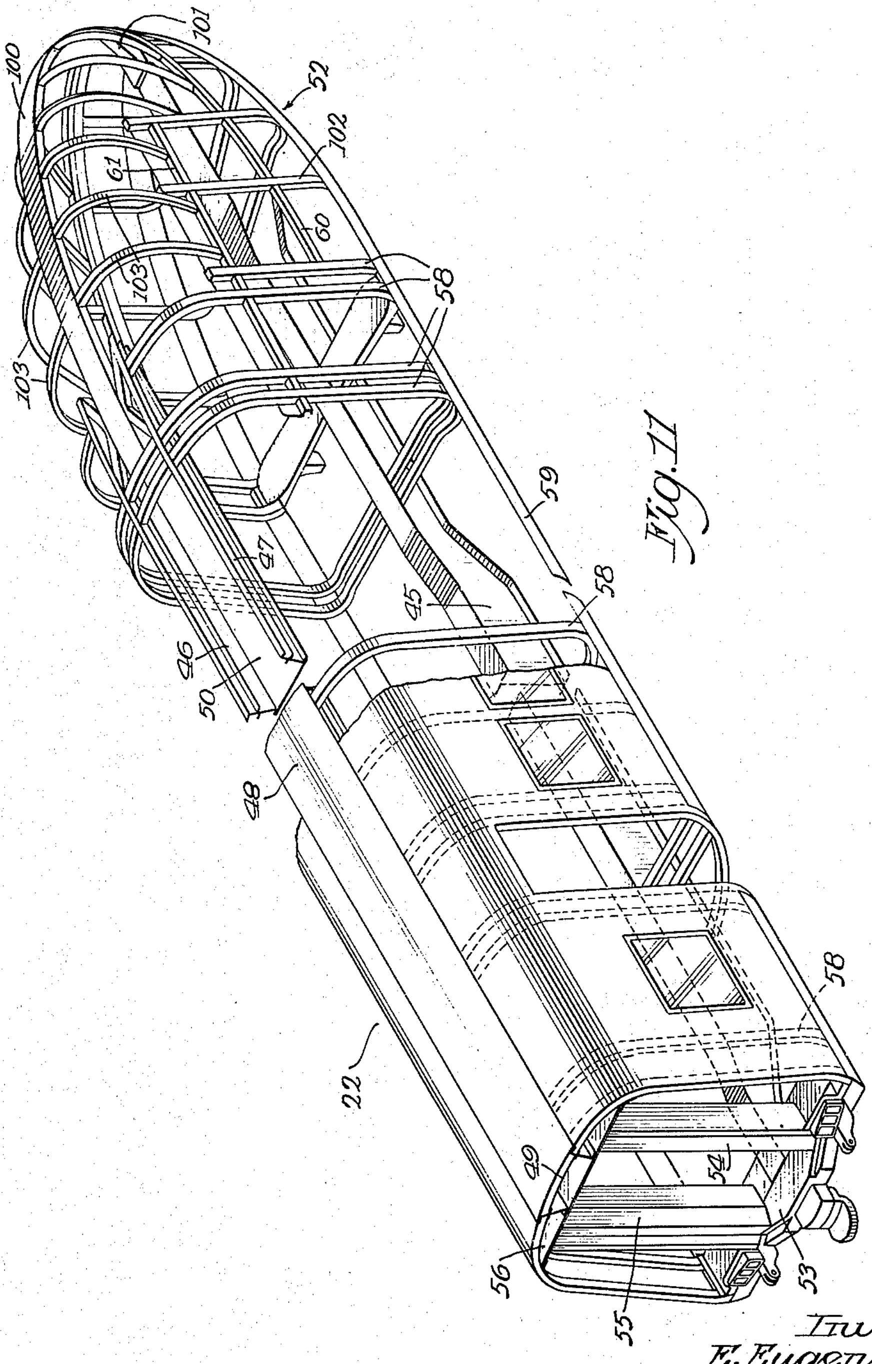
Fig. 10

Inventors
E. Eugene Adams
William B. Stout
William H. Mussey
Martin P. Blomberg
By Wilson, Mann & Cox Attys.

Sept. 21, 1937. E. E. ADAMS ET AL 2,093,535

RAIL CAR

Filed May 28, 1934 6 Sheets-Sheet 6



Inventors
E. Eugene Adams
William B. Stout
William H. Mussey
Martin P. Blomberg
By Gielson, Mann & Co. Attys.

Patented Sept. 21, 1937

2,093,535

UNITED STATES PATENT OFFICE

2,093,535

RAIL CAR

Everett Eugene Adams, Martin P. Blomberg, and William H. Mussey, Chicago, Ill., and William B. Stout, Detroit, Mich., assignors to Pullman-Standard Car Manufacturing Company, Chicago, Ill., a corporation of Delaware

Application May 28, 1934, Serial No. 727,950

2 Claims. (Cl. 105—2)

The application of the principles of aero-dynamics to railway cars presents some real difficulties. In the first place, it is necessary to take into consideration that a railway car travels adjacent to a fixed surface (as distinguished from an airplane) and that the ties and ballast of the right-of-way offer very substantial resistance to air flow beneath the car. It is, therefore necessary to minimize this source of resistance if effective streamlining is to be obtained.

But there are many other considerations which influence the final result. For example, the cross sectional shape of the car must be such that it comes within the clearance line prescribed by the American Railway Association (indicated in Fig. 6), the car must have a low center of gravity; it must have appropriate load carrying space; the structural design must meet the limitations imposed by the strength of the materials used; suitable truck clearances must be provided; all these things must be blended with the fundamentals of aero-dynamics in order to have a practical car construction; and last but not least, the car must present a pleasing appearance to the ordinary person.

The principal object of this invention, therefore, is to provide a car body which utilizes the principle of aero-dynamics to the fullest extent consistent with the above considerations.

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-section articulated car made in accordance with the invention;

Fig. 2 is a side elevational view of the same;

Fig. 3 is an enlarged side elevational view of the motor car section, a part being broken away to show the control cab and engine room arrangement;

Fig. 4 is an enlarged side elevational view of the rear portion of the car;

Fig. 5 is a front perspective view of the motor car section;

Fig. 6 is a front, elevational view of the same;

Fig. 7 is a perspective view of the engine bed;

Figs. 8*a* to 8*j* are diagrammatic cross sectional views illustrating the shape of the car at the section lines *a—a*, *b—b*, etc. respectively, indicated in Fig. 2; and

Figs. 9, 10, and 11 are perspective views showing the framework of the leading section, intermediate section, and trailer section, respectively.

For the purpose of disclosure, the invention has been shown applied to a multi-section articulated car, but the invention is equally applicable to a single car unit. The appended claims are, therefore, to be construed broadly unless a narrower construction is necessary to avoid the prior art.

The car comprises a leading or motor section **20**, an intermediate section **21**, and a trailer section **22**. The adjacent ends of the first and second sections and the adjacent ends of the second and third sections are articulated and are supported on trucks **23** and **24**, respectively. A motor truck **25** supports the front end of the motor or leading section **20**, and a trailer truck **26**, the rear end of the trailer section **22**.

The space between the car sections is closed by a shield **27** overlapping a forwardly extending flexible canopy **28** that is resiliently urged to the fore by springs or equivalent means. The shield and canopy at each articulated joint conform to the cross sectional shape of the car.

Further details of the diaphragm arrangement between car sections may be found in the copending application of Martin P. Blomberg, and Wm. H. Mussey, Serial No. 717,417, filed March 26, 1934, now Patent No. 2,056,227, issued October 6, 1936, for Articulated car, the disclosure of that application being hereby made a part of this disclosure.

The motor section **20** has an elevated control cab **29** which affords good visibility for the car operator. An engine room **30** is directly in rear of the control cab and it provides space for an internal combustion engine **31**, preferably a distillate burning or Diesel engine, which drives a generator **32** which in turn supplies current for driving electric motors, not shown, on the motor truck **25**.

A trough **33** is formed in the roof of the engine room directly above the engine **31**, and cooling radiators **34** are placed on opposite sides of the trough immediately beneath the roof. The engine muffler **35** rests in the trough, as shown in Fig. 1.

The radiators **34** are cooled by air drawn by fans **36** through grilles **37** in the nose of the car, the air passing beneath the control cab **29** and sweeping over the engine and radiators and then being discharged to the atmosphere through openings **38** in the side walls of the trough **33**. The fans **36** (there being one for each of the grilles **37**) are driven from the armature of the generator **32** and they build up a static pressure in the engine room which effects a continual circulation of air over the engine and cooling radiators.

The general cross sectional shape of the car is ovate rotundate, as best shown in Fig. 8e, which is a typical cross sectional view through the car body. The nose of the car may be said to be semi-pyriform in side elevation and parabolic in plan. The tail of the car is substantially parabolic in plan and in side elevation the roof of the car slopes gradually downwardly to form a blunt point at the rear end of the car.

Before attempting to discuss the reasons for these particular shapes, it will be helpful at this point to describe in a general way the framing of the three car sections.

All of the car sections are characterized by what may be termed trapezoidal framework lying substantially along the center line of the car, this framework comprising a center sill 45, a pair of top sills 46 and 47 joined by plates 48, 49 and 50 which make the top sills in effect a box girder, and end framework which joins the top sills to the center sill at opposite ends of the car. In the motor car section 20, nose framework, generally designated 51, accomplishes this function at the front end of the car, and in the trailer section 22, tail framework, generally designated 52, accomplishes a like function at the rear end of the car. The other ends of the car sections which include the rear and front ends of the motor and trailer sections, respectively, and both ends of the intermediate section, have framework consisting of an end sill 53 which is rigidly united with the center sill 45, door end posts 54 and 55 rising from the end sill 53 and securely united thereto, and a top plate 56 which rests upon the door end posts 54 and 55, and supports the ends of the top sills 46 and 47. Gusset castings 57 provide means for fastening the top sills to the top plate.

This main framework is supplemented by curved ribs 58 which emanate from the top sills and terminate adjacent to the top of the center sill 45. These ribs are spaced at intervals throughout the length of the car and serve as combined carlines, side posts and floor supports. Obviously, the ribs may be made in more than one piece if desired.

Side sills 59 extending longitudinally from the extremities of the end sill 53 connect the lower portions of the ribs 58 and hold them in proper spaced relation. Other longitudinal framing members, such as belt rails 60, window headers 61, deck stringers 62 and roof stringers 63 run continuously throughout the length of each car section and maintain the ribs 58 in their proper position. These longitudinal framing members, of course, take much of the longitudinal stresses travelling from one end of a car section to the other.

The bottom of the car has a rounded belly formed by arcuate bars 64 which extend between the side sills 59 and the lower portion of the center sill 45.

The car sections are covered with a metal sheathing 65 which is securely riveted or otherwise fastened to the skeleton framework so that it may serve as a stress member. It is particularly useful as such at the car belly where the metal sheathing is under considerable tension.

All parts of the car framing are preferably made of aluminum, some being extruded aluminum sections and others being aluminum castings. Steel castings, however, moy be used where exceptional strength is necessary. The outer skin or sheathing 65 is also preferably of aluminum.

The motor car section 20 is necessarily framed somewhat differently than the other sections due to the engine load which it must carry. The framing that is preferably used is shown in Fig. 9, and consists of a box frame 70 having an opening 71 adapted to receive the engine 31 which is mounted above the center bearing 72 of the motor truck 25. The engine is mounted on a bed, generally designated 73, which is adapted to be detachably secured to the box frame 70.

The purpose of this arrangement is to facilitate the removal of the engine 31 for repair or replacement, the removal being accomplished by lifting the car body from the truck 25 after removing the fastening means between the engine bed and the frame 70.

The frame 70 consists of cross ties 74 and 75, the former being secured to the front end of the center sill 45. The cross ties are joined by stringers 76 and 77 which are secured to the side sills by short bars 78 and castings 79.

A pair of buff sills 80 and 81 extend forwardly from the front cross tie 75 to a coupler casting 82 to which the ends of the side sills 59 are also secured, as well as diagonal braces 83 and 84, and a ridge beam 85 extending upwardly and rearwardly to the cab framework 86. Heavy plates 87 on opposite sides of the ridge beam reinforce and strengthen the nose structure, these plates being fastened at their lower ends to the buff sills 80 and 81.

A plurality of ribs 88 connect the ridge beam 85 and the cab structure 86 to the side sills 59 to complete the nose structure.

The front ends of the top sills 46 and 47 form the side walls of the trough 33 and connect with a pair of closely spaced ribs 89 and 90 to tie the upper structure to the lower structure.

As will be seen from Fig. 7, the engine bed 73 includes a plurality of extruded longitudinal members combined to form box girders 91 which serves not only to support the weight of the engine but also to transmit longitudinal forces. The purpose of this arrangement is to protect the front end of the car in the event of collision by transmitting the inertia of the engine through the girders or columns 91, cross tie 75, buff sills 80 and 81, and diagonals 83 and 84 to the car nose, the effect being that of a battering ram. Since the operator's cab is somewhat in the rear of the extreme nose portion, it is fairly well protected, but at the same time its location affords excellent visibility.

The tail framework consists essentially of a spinal sill 100 which joins the top sills 46 and 47 to a rear coupler casting 101 at the extreme end of the center sill 45. The ribs at the rear of the trailer section are truncated, as indicated at 102, and other ribs 103 join the spinal sill to various longitudinal framing members, such as the belt rail 60 and window headers 61.

The above description, in a sense, is a preface to the discussion of body shape which follows. It represents the first part of the solution of the main problem, i. e. the combining of streamline form to the exigencies of railway car construction. The problem now considered is the particular application of aero-dynamics to a car of this type.

Referring now to Figs. 8a to 8j inclusive, it will be seen that one common characteristic of all cross sectional forms is the sloping side walls. Also, it will be observed that the roof of the car merges into the side walls with a smoothly rounded curve (Figs. 8b and 8c being exceptions, these figures being taken in the vicinity of the cab) and that the belly of the car is continuously curved from side wall to side wall, with the lowest part of the curve occurring at the center line of the car (there being exceptions at the trucks due to the necessity for providing truck clearance and at the nose of the car for reasons which will later be described).

This generally ovate form satisfies the requirements of load carrying capacity and passenger comfort (ample room being provided near the bottom for seats, and the more limited headroom being unobjectionable) and more important, this shape is particularly advantageous in reducing wind resistance to a minimum. It has been found experimentally that a 16° headwind not only creates more wind resistance than any other angle of air current, but also that it has the greatest tendency to overturn a car. By making the cross sectional shape of the car ovate, the center of gravity is kept low and side winds can pass over and beneath the car body with minimum effect. The generally ovate form of the car, therefore, is particularly advantageous in combating angular headwinds.

The car, with its component sections, each of which has a length approximately that of a conventional railway car (60 feet more or less) is of ample length so that when the streamlined nose of the car strikes an angular headwind, the relatively slight turbulence set up does not materially affect the useful purpose served by the cross sectional shape of the car.

The transverse cross-sections, taken adjacent the ends of the car, are more truly egg-shaped or ovate than the intermediate sections, but for convenience the term ovate will be used to designate the characteristic shape which includes upwardly tapering side walls and smoothly rounded top and bottom walls.

As the intermediate sections are fuller and more nearly round than the end sections, the term ovate rotundate may be used to more specifically describe their shape.

The term "ovate rotundate" wherever it appears in the appended claims is used in the sense above described. This term also implies that the car has its greatest width in the region of the floor level and a smaller width in the region of the roof level; also that the curve which joins the bottom of the car to the side walls is of substantial radius as distinguished from a mere filleted edge, with the result that winds striking the car at an angle are passed beneath the car with ease and without turbulence, thus effectively reducing drag and equalizing to some extent the pressure differential on opposite sides of the car.

It will be understood that a car body may have an "ovate rotundate" cross-sectional form although the lower portions of the side walls (above the lower curve) are substantially vertical. The essential relationship defined by the term "ovate rotundate" is that the body is shaped (consistent with the above) so that when a horizontal wind strikes the car at an angle with respect to the longitudinal axis of the car, there will be a substantially greater tendency for the air to pass over the car than beneath it (disregarding the spacing of the car body from the ground), but that in either case, the air is guided in its path across the car by smooth broadly rounded unobstructed surfaces. It is this increased tendency for the air to pass over a car of ovate rotundate form rather than beneath it and the spacing of the car body from the ground so that substantial quantities of air can pass beneath the body, that lowers the center of pressure as compared with a car of similar dimension that does not have this tendency (as for example Adams 489,912 and Zimmerman 542,746).

When a vehicle such as a rail car is travelling at a high rate of speed, a certain amount of air is trapped beneath the car, and if the car bottom is relatively flat, a static pressure is built up which tends to lift the car from the track. This tendency is overcome in the present case by having the car bottom rounded with the apex of the curve at the center line of the car. In this way, the air column beneath the car is divided and the building up of static pressure is avoided.

The nose of the car is shaped to accomplish the mechanical functions already stated, to give a pleasing appearance, and to reduce wind resistance. To this end, the side sills 59, the ridge beam 85, the ribs 58 and other structural members of the nose are curved so that in plan the general shape is parabolic, in side elevation, semipyriform, and in end elevation, more or less circular, but changing to ovate as it merges with the main portion of the car body.

The pilot 106 directly beneath the nose serves not only to keep the track clear for the trucks, but also to direct air in the vicinity of the tracks to the sides of the car. In this way, the air is diverted from passing beneath the car where it would tend to build up static pressure and produce turbulence, both of which actions are undesirable from the standpoint of reducing car resistance.

All of the trucks are equipped with skirts or shrouds 107 to further reduce wind resistance. It has been found by wind tunnel tests that a further substantial saving in power can be achieved by reducing wind resistance at the trucks to a minimum.

What we claim is:—

1. A railway car for ground rail service having smooth, continuous, and substantially unobstructed surfaces and characterized by its stability to side and oblique winds, said car comprising a car body spaced from the rail a sufficient distance that substantial quantities of air may pass transversely beneath the car body, said body having a substantially uniform ovate rotundate cross-sectional form from end to end which gives the car body a relatively low center of pressure and which permits side and oblique winds to pass above and below the car body with relative ease and minimum turbulence, the car being of sufficient length so that the ovate rotundate cross sectional form of the car lessens the tendency of said winds to overturn the car, the car body having its greatest width in the region of the center of pressure and having inwardly sloping side walls which merge at the top with a broadly curved roof sheet and at the bottom with a broadly curved bottom sheet, said bottom sheet being substantially continuously curved from side wall to side wall with the lowest portion of the curve at the car center line, thereby preventing air pressure from building up beneath the car.

2. A railway car for ground rail service having smooth, continuous, and substantially unobstructed surfaces and characterized by its stability to side and oblique winds, said car comprising a car body spaced from the rail a sufficient distance that substantial quantities of air may pass transversely beneath the car body, said body

having a substantially uniform ovate rotundate cross-sectional form from end to end which gives the car body a relatively low center of pressure and which permits side and oblique winds to pass above and below the car body with relative ease and minimum turbulence, the car being of sufficient length so that the ovate rotundate cross sectional form of the car lessens the tendency of said winds to overturn the car, the car body having its greatest width in the region of the center of pressure and having inwardly sloping side walls which merge at the top with a broadly curved roof sheet and at the bottom with a broadly curved bottom sheet, said bottom sheet being substantially continuously curved from side wall to side wall with the lowest portion of the curve at the car center line, thereby preventing air pressure from building up beneath the car, and a pilot at the nose of the car for dividing the air in the vicinity of the rails.

E. EUGENE ADAMS.
MARTIN P. BLOMBERG.
WILLIAM H. MUSSEY.
WILLIAM B. STOUT.