

June 28, 1960

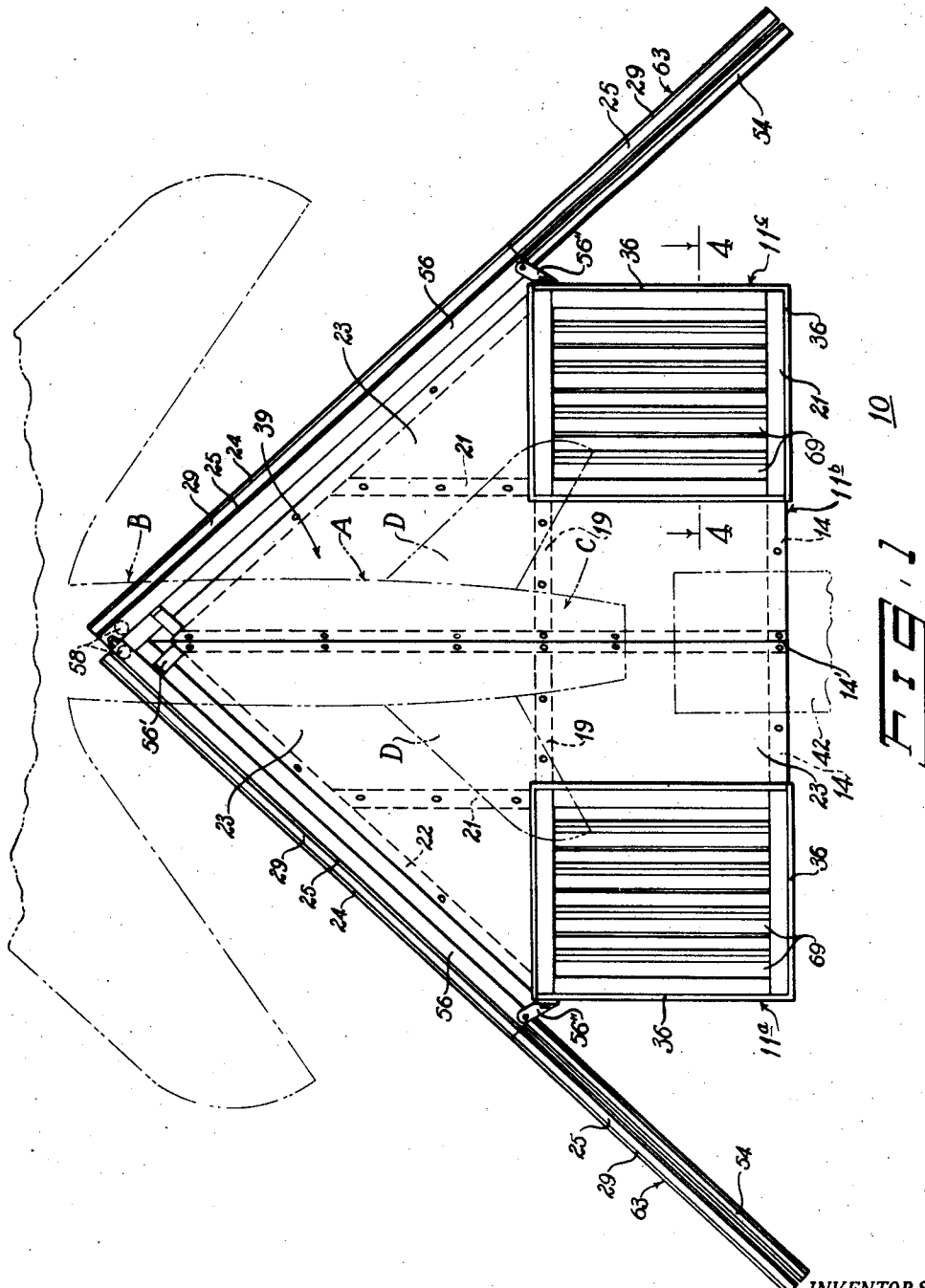
R. C. BERGH ET AL

2,942,682

SOUND-PROOF ENCLOSURE

Filed Dec. 21, 1956

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

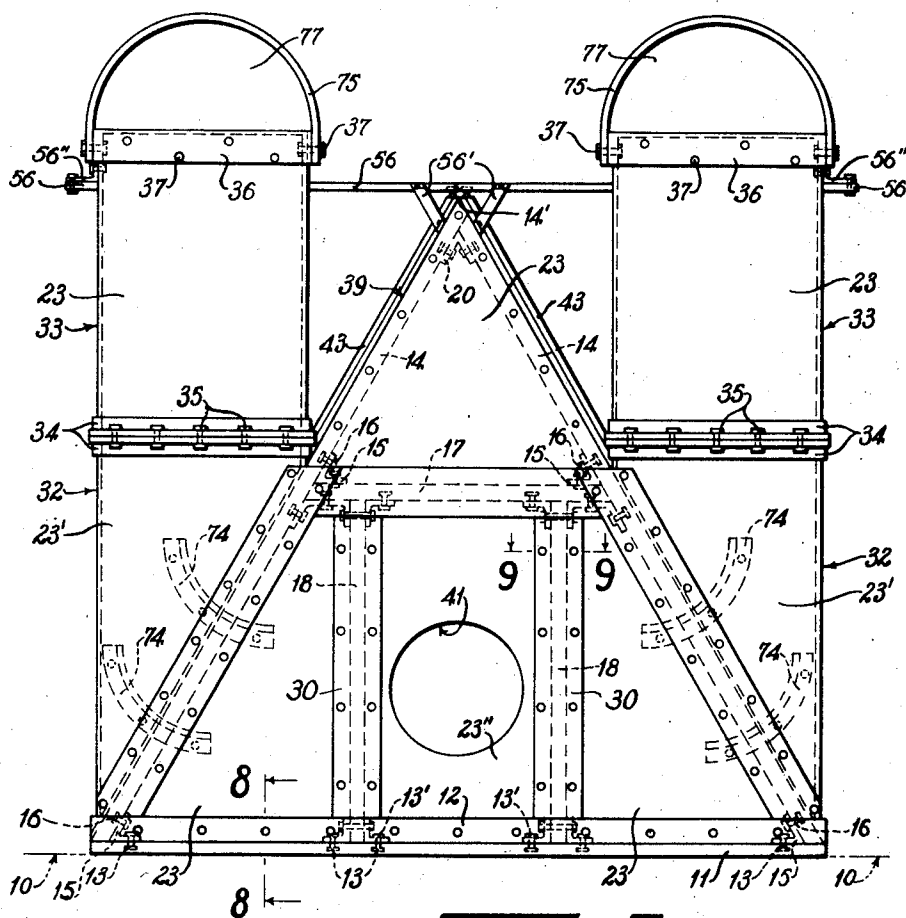


FIG. 2

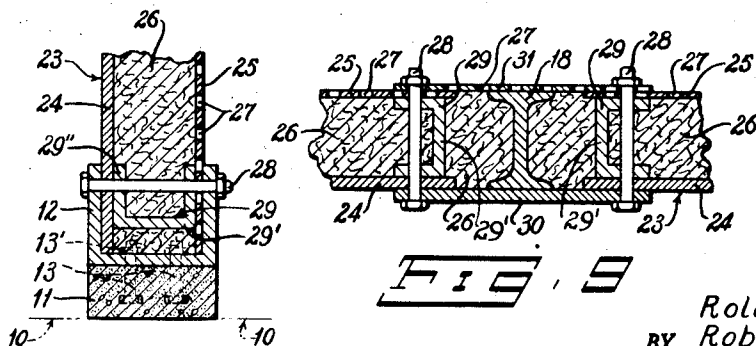


FIG. 3

FIG. 4

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4 Sheets-Sheet 4

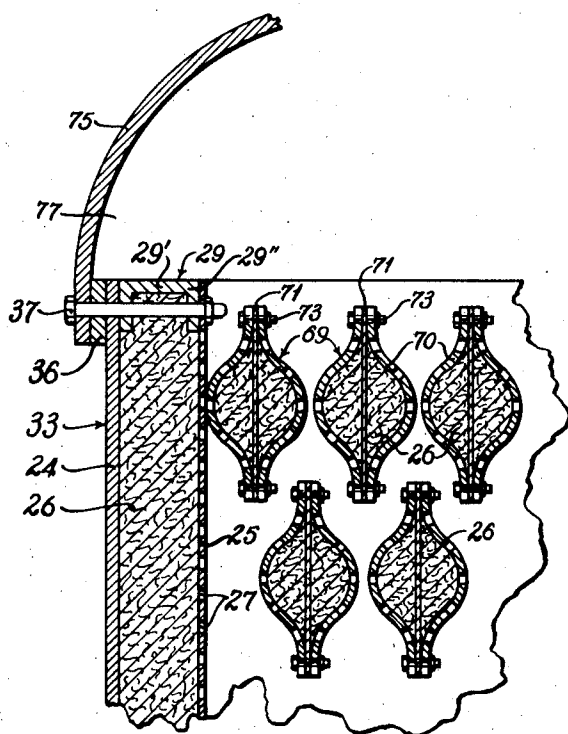


FIG. 4

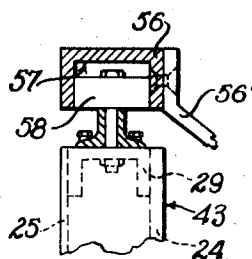


FIG. 10

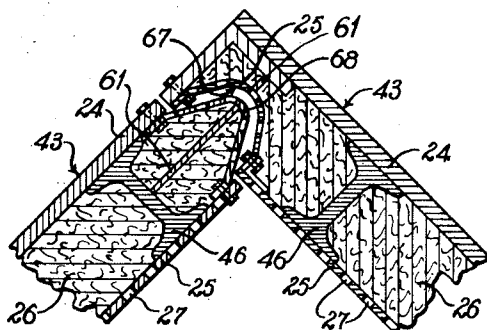


FIG. 7

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2,942,682

SOUND-PROOF ENCLOSURE

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12 Claims. (Cl. 181—35)

This invention relates to sound-proof enclosures and more particularly to a sound-proof enclosure for the discharge end of an exhaust pipe of a jet engine whereby noises created by and emanating from said engine during warm-up and/or test operations are eliminated or suppressed.

More specifically, the present invention contemplates an enclosure fabricated of sound-absorbing material adapted to house and operatively connect in spaced, aligned relationship the discharge end of the engine exhaust pipe of a jet airplane to an associated ground muffler assembly whereby substantially all of the exhaust gases from the engine are directed into the muffler assembly and the bulk of the accompanying noise diffuses at the exit of the exhaust pipe within the enclosure where it is quickly dispersed and absorbed.

In addition, the design of the present enclosure is such that it effects the maximum dispersion of the noise leaving the engine exhaust pipe to thereby distribute it equally throughout all parts of the enclosure. At the same time its design and construction is such that it is capable of withstanding the external loads imposed by weather conditions including high winds, as well as the internal loads due to the forces and pressures resulting from the exhaust gases passing through it at relatively high velocities.

Also, this enclosure is so constructed and assembled that it may be quickly and readily disassembled and shipped, transported or moved and reassembled in a new location.

Among its other objects, the instant invention contemplates means by which the enclosure is adapted for use in conjunction with airplanes and muffler assemblies of various sizes, types and designs.

With the above and other objects in view, as will be apparent, this invention consists in the construction, combination and arrangement of parts all as hereinafter more clearly described, claimed and illustrated in the accompanying drawings, wherein:

Fig. 1 is a plan view of the present enclosure showing the aft end of a jet airplane and the extremity of the inlet duct of an associated ground muffler assembly in phantom;

Fig. 2 is a rear elevation of the instant closure illustrating inter alia, one of a series of removable and interchangeable adapter panels mounted therein for the connection of the inlet duct of a muffler assembly to the enclosure;

Fig. 3 is a side elevation of the enclosure showing inter alia, one of a series of removable and interchangeable adapted panels mounted in the forward end thereof for the connection of the closure to the aft end of an airplane;

Fig. 4 is a fragmentary longitudinal section through one of the air inlets to or stacks for the enclosure adjacent the outer end thereof to show the construction of one type of baffle arrangement which may be disposed transversely thereof and to further show a protective

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cover secured to its outer end to prevent the admission of rain, snow and the like therein;

Fig. 5 is a transverse section taken along line 5—5 of Fig. 3 to show the supporting, mounting and main guide means for each door-half of the enclosure by which it may be readily moved to and from the open and closed positions and the seal associated therewith to prevent the escape of sound therethrough;

Fig. 6 is a section taken along line 6—6 of Fig. 3 to show the means employed at and along the edge of the enclosure and the associated edge of each door-half to prevent the escape of sound therethrough when the door-halves are disposed in the closed position;

Fig. 7 is a transverse section taken along line 7—7 of Fig. 3 through the adjoining edge portions of the door-halves when disposed in the closed position to show the overlapping relationship therebetween whereby the joint thereof is effectively sealed against the escape of sound;

Fig. 8 is a section taken along line 8—8 of Fig. 2 to show the means by which the enclosure is removably secured or anchored to a supporting surface upon which it is located;

Fig. 9 is a fragmentary section taken through adjacent edges of the walls or covering sections which define the enclosure to show the construction and manner of interconnection thereof; and

Fig. 10 is a section taken along line 10—10 of Fig. 3 to show the auxiliary guide means to control the path of movement of each door-half in moving to and from its open and closed positions.

To suppress or abate the noise created by the jet engine of aircraft, various sound-reducing devices have been employed. One of the more successful of these devices is a ground muffler assembly designed and adapted to cooperate with the aft or discharge end of the exhaust pipe of the airplane engine and receive the entire discharge thereof. These muffler assemblies may be fabricated of sound-absorbing material but are preferably made of metal and are so constructed and arranged that the exhaust gases and accompanying noises emanating from the engine are directed through the muffler assembly. The exhaust gases are discharged at the aft end of the muffler, while the noises are substantially dispersed or diffused throughout the muffler and largely suppressed thereby.

It has been learned, however, that these muffler assemblies are not completely effective due to the great force and pressure of the gases exhausted from the engine. Thus, when the opening at the aft end of the muffler is sufficiently large to allow a rapid discharge of the exhaust gases to atmosphere and thereby prevent a reversal of flow or back-up thereof, the opening is not at the same time small enough to prevent the emission of considerable sound through it.

The present invention overcomes the foregoing objections, among other things, and proposes a sound-proof enclosure disposed about the adjacent ends of the engine exhaust pipe and muffler. This enclosure completely contains and houses the aft end of the airplane and the associated end of the muffler, which ends are operatively connected thereby in predetermined, spaced relationship. With the aft end of the airplane and the forward end of the muffler assembly so connected, all of the exhaust gases discharged from the engine of the airplane are directed into the muffler while the accompanying noises are confined and disperse at the aft end of the airplane and around the forward end of the muffler and are diffused throughout the enclosure.

Hence, only a relatively small amount of the noise from the airplane engine passes into the muffler assembly thereby permitting the enlargement of the discharge open-

ing in said muffler for substantially unrestricted flow of exhaust gases therethrough. This eliminates any possibility of the exhaust gases backing up or having reverse flow that might damage the engine. At the same time, the bulk of the noise discharged from or developed by the airplane engine is confined and absorbed by and within the enclosure while the remainder of the noise enters the muffler with the exhaust gases and is absorbed therein.

The spaced relationship between the discharge end of the engine exhaust pipe and the muffler inlet as herein proposed further lends itself to the comparatively quick solution of problems encountered in the operation of prior devices. In the prior muffler assembly hereinabove referred to, for example, the heat of the exhaust gases to which the internal structure of the muffler is subjected can be and is intolerable. The temperature of these gases is commonly 1400° Fahrenheit and upward which considerably exceeds the thermal capacity of presently existing materials that are employed in the fabrication of these mufflers.

In the instant enclosure air intake openings or stacks, which are effectively sound-treated and thereby closed to prevent the escape of noise, are provided for the admission of predetermined amounts of atmospheric air to the enclosure for mixture with the exhaust gases discharged from the tail pipe and passing into the muffler inlet. The velocity of these gases serves to draw this air entering the enclosure into the muffler inlet along with the exhaust gases to appreciably decrease the temperature thereof within the muffler.

Moreover, the present enclosure is designed to present minimum internal areas defined entirely by angularly disposed walls whereby the noise is confined and suppressed and more quickly dispersed. Since the resultant sound is a function of the distance between the exhaust end of the airplane and the walls of the enclosure together with the total area of the walls, the noise within the enclosure is suppressed due to this minimum internal area. Also, since no two walls are parallel but are each angularly disposed relative to the others, sound waves striking them and which are not immediately suppressed thereby are deflected to cause their rapid dispersion and diffusion throughout the entire enclosure thus preventing the formation of standing sound waves and destructive resonance of the airplane structure confined therein.

Additionally, due to the velocity of the exhaust gases from the airplane engine into the muffler assembly, a vacuum is created within the enclosure and the resulting suction tends to pull or draw the house inwardly. Therefore, the construction of the present enclosure is such that it will withstand considerable internal forces and pressures as well as those to which it may be subjected as a result of external forces and pressures caused by variable weather conditions such as high winds or gales and the like.

The invention offers the solution to all of the foregoing problems and in addition proposes an enclosure of the type described which is of knock-down construction, i.e., may be readily assembled or quickly dismantled and packed or moved and reassembled an unlimited number of times.

Referring more particularly to the drawings, 10 designates the ground line or other supporting surface upon which the enclosure is to be mounted or erected (Figs. 2 and 3). A relatively narrow, raised footing or sill 11 is anchored or otherwise secured in any suitable manner to the supporting surface 10 with its upper surface lying in a single plane to thereby form a continuously level foundation for the enclosure.

When the supporting surface 10 is paved the footings 11 may be formed integrally therewith or may comprise a step or riser formed on blocks or piles of concrete embedded or sunk in the ground and surrounded by pavement. In any event the footing 11 projects from or is raised above the supporting surface 10 and defines three

sides 11^a, 11^b, and 11^c (Fig. 1) of a generally rectangular area. At spaced intervals along the length of the footing 11 lag bolts 13 are provided. The head of each of these lag bolts 13 is buried in or otherwise secured to the footing 11 and at its opposite end the lag bolt is threaded and projects upwardly from the footing.

A channel 12 opening upward is disposed on the footing 11 with its base resting flush against the top surface of the footing, a hole being provided in said base corresponding in position to each lag bolt 13. Thus, the bolts 13 pierce the base of the channel 12 to secure it to the footing 11 by the nuts 13' operative on the projecting threaded ends of the bolts 13. The channel 12 is thus removably secured to and is coextensive with the footing or sill 11.

A structural member, e.g. an I beam 14, is disposed with one of its ends abutting the inner surface of the channel 12 at each of the corners of the footing or sill 11 (Fig. 2). This end of each beam 14 is angularly cut so that when each of the beams 14 is located as aforesaid, their opposite or upper ends converge and come together as at 14', thereby define a triangular area as the rear wall of the enclosure.

An angle plate 15 is employed at each intersection of the beams 14 with the channel 12. One side of this plate 15 is secured to the channel 12 by one of the bolts 13 while its opposite side is secured to the beam 14 by the bolt 16.

Medially of the length of the beams 14 a transverse structural member or I beam 17 is interposed between the beams and disposed directly above and substantially parallel to the channel 12. The ends of the beam 17 are angularly cut to abut the associated faces of the beams 14 to which they are removably secured by angle plates and bolts similar to the plates 15 and bolts 16. At least two spaced members or I beams 18 are interposed between the channel 12 and beam 17 and are similarly connected at their ends to the beam 17 and to the channel 12 thereby adding structural rigidity to the assembly.

A pair of converging and interconnected beams 19 similar to the beams 14, are disposed at the opposite extremities of sill 11 to thereby lie in spaced relationship from and parallel to the beams 14 (Figs. 1 and 3). These beams 19 at their lower ends are each connected to the end of the channel 12 by the lag bolts 13 and hence through the channel 12 to the lower ends of the beams 14. Thus, the beams 19 are removably secured or anchored to the sill 11 by lag bolts 13 in the same manner as already described in connection with the beams 14.

Where the respective beams 14 and 19 join they are removably connected adjacent the apexes formed thereby by a horizontal structural member, such as an inverted V beam 20 disposed within the included angles formed by the several beams. The length of the beam 20 is such that one end thereof terminates in the plane of the rear edges of the beams 14 while the other end extends beyond or forward of the beams 19 as will be described.

Finally, the beams 14 and 19 are removably interconnected medially of their length by means of and through a horizontal member or I beam 21 (Fig. 3), which is secured to corresponding beams 14 and 19 by angle plates like 15. Each of the beams 21 is thus disposed at right angles to and in abutment against the adjoining end of the beam 17. One beam 21 lies under and in contact with the beams 14 and 19 on each of the areas defined by these beams and the length thereof is such that it extends in the forward direction beyond the beam 19.

At its forward end each beam 21 terminates approximately midway of the distance between the converging beams 19 and the forward end of the beam 20. An I beam 22, removably secured at one of its ends to one end of the sill 11 adjacent the associated beam 19, is disposed at an angle intersecting the forward end of a horizontal beam 21 and the V-beam 20. The outer or upper

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ends of these beams 22 converge and join in an apex like the apex 14' of the beams 14 and have their flanges abutting the end of the V-beam 20. Angle plates similar to the plates 15 may be employed to removably secure the abutting ends of the beams 20 and 21 to the beam 22.

The foregoing constitutes the frame or skeleton of the present enclosure per se. Dismantling may be readily accomplished by removal of the several nuts from their respective bolts 13 and 16 whereby the elements which comprise the frame may be packed for storage or shipped and reconstructed or reassembled in a new location. It is to be noted, however, that while I beams have been hereinabove described in the preferred construction, many other types of structural members may be employed with substantially equal results and without departing from the scope of the present invention.

Moreover, the invention contemplates an internal area within the enclosure per se as defined particularly by the beams 14, 19, 20 and 21 of minimum size to accommodate the aft end portion of the jet engine exhaust pipe. In the illustrated form of the invention this area is also large enough to enclose the empennage or tail section A (Fig. 1) of a single engine jet airplane B wherein the exhaust pipe is located in the aft end of the fuselage C. Thus, the height of the apexes 14' of the converging beams 14 and 19, as well as the included angle thereof, is just sufficient to dispose these beams safely clear of the vertical and horizontal fins D of the airplane B when located therein.

When the frame or skeleton has been thus constructed or assembled, it is enclosed or covered with panels or composite sections 23 including suitable sound-absorbing material. Each of these panels 23 may, for example, comprise a pair of spaced sheets 24 and 25 having a fibre glass blanket or filler 26 sandwiched therebetween (Fig. 8). Sheet 25 which is disposed within the enclosure and thus forms the inner wall thereof is pierced by a plurality of spaced perforations 27 which admit the sound waves to the blanket or filler 26.

Each of the composite panels 23 may be assembled as a unit in any desired manner, such as for example, by a suitable number of screws or bolts 28 passing through the sheets 24 and 25 and the filler or blanket 26. Similarly the elements of each panel 23 are removably secured adjacent its edges to an underlying U beam 29 positioned within the space defined by the sheets 24 and 25 whereby the connecting web portion 29' thereof closes the edge of the panel with the flanges 29'' thereof secured to the inner faces of the opposed sheets 24 and 25 by the bolts 28. Where it is desired to employ multiple sheets 23 or it is otherwise necessary to interconnect adjacent sheets 23 directly one to the other, for example in order to intersect and enclose the several I beams 14, 18, 19, etc., this is accomplished by an overlapping arrangement, as shown in Fig. 9.

More specifically, the adjoining panels 23, being disposed in the plane of an associated I beam terminate on opposite sides thereof with the outer surfaces of its sheets 24 and 25 in a common plane with each other and with the corresponding surfaces of the I beam such as 18. Cover strips or plates 30 and 31 identical in thickness and construction to the sheets 24 and 25 of the panel 23 overlap the adjoining ends of the panels 23 and each serves to continue and extend its respective sheet 24 or 25 with its inner face flush against the associated surface of the I beam 18. A number of holes may be provided in the strips 30 and 31 along and adjacent the edges thereof to correspond to and align with some of the bolts 23 holding the U beams 29 in place. These bolts pass through the plates 30 and 31 and the filler 26 whereby the strips, sheets 24 and 25, filler 26 and U beams 29 are all secured together to form a unitary panel 23. Packing material like 26 may be also sandwiched between the strips 30 and 31 on opposite sides of the I beam 18.

Thus, the frame or skeleton is enclosed by interconnect-

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ing a number of sound-absorbing composite panels 23 one to another (Fig. 9) and to the channel 12 (Fig. 8), to extend vertically therefrom. At each side of the sill 11 is a vertical stack or air inlet 32—33 the walls of which are fabricated of panels 23. The lower portion 32 of each stack has a rectangular side panel 23 extending upwardly from the adjoining channel 12 of the sill 11 with a similar side panel 23 forming a vertical continuation thereof in the upper portion 33 of the stack. Between the edge of the rectangular side panel 23 of the lower portion 32 of the stack and the adjacent beams 14 and 19 is a triangular panel 23' connected at one edge to the edge of the rectangular side panel and at its opposite edge to the beam 14 or 19, as the case may be. Above each such triangular panel 23' and forming a continuation thereof is a rectangular panel 23 forming a side of upper portion 33 of the stack. The other side of the upper portion 33 of the stack is formed by a rectangular panel 23 and all openings which may occur in this assembly are closed by sections constructed the same as the panel 23.

Each of the lower portions 32 of the stacks terminates at a point just above the plane of the beams 17 and 21 (Figs. 2 and 3) and in a common plane one with the other. The upper portion 33 of the stack, formed by four rectangular panels 23 and having a cross-section identical to that of the upper end of the lower portion 32 is mounted thereon in edge-to-edge abutment to thereby extend and continue the lower portion 32 to a height approximately equal to that of the peak 14' of the central portion of the enclosure. Complementary angle plates 34 are employed at and along the marginal edges of the adjacent ends of the upper and lower portions 32 and 33 of the stack for the interconnection thereof by means such as the bolts 35. At their other or upper ends the panels 23 which combine to make up the upper portion 33 of the stack may be joined and secured one to the other by the bands 36 secured thereto by any suitable means 37. Thus, the stacks 32—33 like the frame or skeleton and attached parts, may be dismantled for storage or shipment.

The foregoing construction constitutes the main portion of the present enclosure which may be summarized generally as consisting of a peaked or triangular central part 39, having a part 40 consisting of the beams 20, 21 and 22 and attached panels 23 projecting therefrom (Fig. 3). This central part 39 is flanked by a pair of stacks (32—33) formed and mounted as above described. The forward end 40 of the enclosure is unobstructed as will be described.

A special series of sections or panels 23'' is provided to fill and close the aft end wall of the enclosure in the area between the vertical beams 18. All of these panels 23'' have the same overall dimensions and are otherwise identical one with the other to the end that they may be selectively and interchangeably secured or bolted in place in the manner shown in Figs. 8 and 9. Each of these panels 23'' is pierced centrally by an aperture 41 of different size and/or shape to correspond to the external size and shape of an inlet duct or pipe 42 of different muffler assemblies to the end that said pipe 42 may pass therethrough and be immovably retained therein.

Thus, when it is desired to employ a muffler assembly of a particular size with the enclosure, a panel 23'' having the corresponding sized aperture 41 is operatively installed in the rear wall of the enclosure between the beams 18 by means of the bolts 13 and 28 as already described. Upon completion of the use of the selected muffler assembly, it may be readily removed from and/or replaced by an alternative panel 23'' for cooperation of the enclosure with a different sized muffler assembly.

At the forward, open end of the enclosure and in cooperation with edge 40' of its extension 40, a movable door assembly is provided. This door assembly comprises a pair of slidable or rolling door halves 43 each

identical with the other, being generally triangular in shape and adapted to move to and from a closed position with corresponding sides thereof in edge-to-edge abutment in the vertical center of the enclosure. Each door-half 43 is formed by a frame of structural members such as I beams similar to those employed in the enclosure per se.

More specifically, a horizontal base beam 44 (Fig. 3) is removably connected at one end to a diagonally disposed beam 45 by suitable angle plates like 15 secured to the adjacent faces of the flanges thereof by bolts 16. The diagonal beam 45 extends beyond the end of the beam 44 connected thereto and is designed to form the rear end of the door-half 43. The angle between beams 44 and 45 is such that beam 45 is disposed in a plane parallel to that of the beam 22 defining the projecting part 40 of the main enclosure 39.

At its outer or upper end, the beam 45 is similarly connected to the upper end of a vertical beam 46 which, in effect, interconnects the beam 45 and beam 44, being removably connected at its other or lower end to the forward end of the horizontal beam 44. The beam 46 actually terminates at a point approximately mid-way between its upper end and the horizontal beam 44. A second vertical beam 47 disposed in spaced relationship from and parallel to the beam 46 is removably connected at its ends to the beams 44 and 45 medially of their length. Beam 47 is connected to the beam 46 by means of and through a horizontal beam 48 which is removably connected at one of its ends to the lower end of beam 46 and at its other end to the beam 47.

The frame of each door-half 43 thus constructed and assembled is covered or enclosed with sound-absorbing panel 23 in the same fashion as above described in connection with the main portion 39 of the enclosure. Thus, composite panels or sections 23 are disposed over and around the several beams 44, 45, 46, 47 and 48 of each door-half, being removably connected thereto by a suitable number of bolts 28.

A special series of sections or adaptor panels 49 is provided to fill the area of each door-half 43 defined by the forward end portion of beam 44, the lower portion of beam 47 and the beam 48. All of these panels 49 have identical overall dimensions to the end that each may be selectively and interchangeably installed in the assembly. However, each panel 49 is provided with a different recess 50 in its forward edge when installed, corresponding in contour to one-half of the external contour of an engine exhaust pipe or airplane component, such as the aft end of the fuselage C, which houses such an exhaust pipe. A liner 51 of neoprene sponge rubber or equivalent material impervious to weather, gaseous fumes and moisture, etc., is affixed in any suitable manner to and around the edge of each panel 49 defining the recess 50 therein. The purpose of such liner 51 is to permit the snug abutment of the panel 49 to the engine exhaust pipe or fuselage C to thereby effect a substantially sealed closure without coincidental damage to either fuselage or panel.

In order that the door-halves 43 may be moved to and from the open and closed positions, each door-half is provided with a marginal recess 52 in its base or bottom edge (Fig. 5). A number of rollers 53 are mounted transversely across this recess 52 at intervals in the length thereof for operation on and over a guide rail 54 fixedly secured by lag bolts 54' to a footing or sill 55 anchored in and projecting upward from the supporting surface or ground 10 in the same manner as that already described in connection with the sill 11. Thus, the several rollers 53 resting on and operative over rail 54 support the entire load or weight of each door-half 43.

At its upper and forward end, each door-half 43 is connected to a guide track 56 which serves to retain it in a vertical position on its supporting rail 54 at all times and in every position in its movement thereon. Each track 56 is secured adjacent its opposed ends to the projecting for-

ward portion 40 of the enclosure at the apex thereof by an angle plate 56' and to the upper portion 33 of the stack 32-33 by a similar angle plate 56'' so that the track 56 is disposed parallel to the rail 54. The bottom edge of each track 56 is channelled, as at 57 (Fig. 10), being an inverted U in cross-section to thereby receive a roller 58 mounted on and projecting upwardly from the top of the door at the forward end thereof. Thus, the roller 59 is confined within the channel 57 of the track 56 at all times and is free to operate therein substantially all of the load of the door-half 43 being supported by the rail 54.

When the door-halves 43 are disposed in the closed position, i.e., the forward edges thereof abut in the vertical center of the enclosure (Figs. 1 and 3), the rear edge of each door-half 43 along the diagonal beam 45 is disposed adjacent to and in overlapping relation with the forward edge of the projecting structure 40 of the enclosure. A seal is provided at this junction to prevent the escape of sound waves from the interior of the enclosure. For this purpose, interlocking projections 59 (Fig. 6) are provided on and extend along the overlapping ends of each door-half 43 and the associated edge 40' of the projecting part 40 of the enclosure.

Each of the projections 59 is constructed following the same practice used in the fabrication of the panels 23, as hereinabove described. Thus, a pair of sheets like 24 and 25 is connected one to the other by a structural beam or channel 29 which extends along one longitudinal edge of each sheet and serves to close the space therebetween. The outer edge of the closed side of each composite member thus formed is disposed in the plane of the edge of its associated door 43 or of the edge 40' of the projecting part 40. Bolts similar to the bolts 28 pass through the door 43 and edge 40' to engage and secure its projection 59 in a fixed position.

At and along their mating edges, however, each of the projections 59 is closed by a perforated sheet 25 secured thereto by a plurality of rivets or bolts 60. Each of these sheets 25 is arcuate in transverse section, the one on the projection carried by the door 43 being concave to matingly receive in slightly spaced relation the convex one carried by and projecting from the edge 40'. At its opposed ends, each of the projections may be closed by an imperforate flat plate or sheet of the same material as the sheets 24.

Disposed centrally in and extending longitudinally of each of the projections 59 is a divider or partition 61. In order to retain each of these dividers or partitions 61 in position within its projections 59, the opposite edges or sides of each may be flanged and riveted or otherwise secured to its associated concave or convex sheet 25 and to the adjacent channel 29. The hollow space thus created on either side of the dividers 61 is filled with sound-absorbing material 26.

In view of the foregoing construction, it is now apparent that upon the closing of the doors 43, the projections 59 at and along the aft end thereof matingly receive the complementary projections at and along the edge 40' of the part 40 of the enclosure to completely close and acoustically seal the joint therebetween. It is equally apparent that the design, construction and cooperation between these projections is such that they, in no way, interfere with or affect the operation of the doors.

In order to similarly seal the doors 43 at their lower ends, projecting members 63, equivalent to projections 59 just described, are fixedly secured to the edge of each door 43 and to the adjacent supporting footing 55. Thus, a channel beam 29 (Fig. 5) is secured or anchored to the footing 55 by lag bolts like the bolts 54' in an upstanding position adjacent to and coextensive with the rails 54. The open side of each of these channels 29 is closed by a longitudinal perforated sheet, like sheets 25, which is transversely arcuate and convex to project upwardly and outwardly of the channel 29 for mating cooperation and

coaction with a complementary and concave sheet or strip on the projection 63 carried by the lower end of the door 43.

The only substantial difference between the projections 63 and the projections 59 lies in the coaction of their elements one with the other. The complementary elements of the projections 59 are adapted to separate and operatively engage one another only when the doors 43 are in their closed position. On the other hand, the complementary elements of the projections 63 are adapted to move parallel one to the other and are engaged one with the other at all times but this engagement is effective to prevent the escape of sound waves only when the doors 43 are closed.

Additionally, the abutting edges of the door-halves 43 terminate in male and female elements respectively for similar mating engagement one with the other when the doors are closed. To this end, a continuous longitudinal groove 67 (Fig. 7) is provided in and along the face of the inner sheet 25 of the composite panel or panels 23 of one of the door-halves 43 adjacent the forward edge thereof. This groove 67 is formed by a concave perforated sheet or strip 25 like those already described in connection with the projections 59 and 63 along the other edges of the doors 43. Similarly, a convex, longitudinal, perforated sheet or strip 68 is provided on and along the edge of the composite panel or panels 23 of the other door-half 43 adapted to project into the groove 67 and thereby acoustically seal the door-halves 43 when located in the closed position as shown in Fig. 7.

By providing the dividers 61 in the projecting members 59 and 63 (Figs. 5 and 6) and in the groove 67 and projection 68 (Fig. 7) and the dividers 71 in attenuators 69 (Fig. 4), sound waves entering through perforated sheets on one side of the divider cannot exit through perforations on the other side.

From the foregoing, it is apparent that when the enclosure is completely assembled or constructed as described with the proper panels 23' and 49 mounted therein and the door-halves 43 in the open position, the aft end or tail section A of an airplane B may be housed therein. In order to facilitate the maneuvering of the airplane into proper position within the enclosure, the invention contemplates the use of guide and track means such as, for example, that disclosed in the copending application of Bergh et al., Serial Number 582,417, filed May 3, 1956. The invention further contemplates tie-down means, such as that disclosed in the above application to secure or anchor the airplane to the supporting surface 10 after it has been disposed in the desired position relative to and within the enclosure.

When the airplane is thus located and secured in position relative to the enclosure and a suitable muffler assembly has been connected to the rear of the enclosure in direct opposition to the airplane with the inlet duct or pipe 42 thereof passing through the aperture 41 of the adapter panel 23', the discharge end of the tail pipe of the engine is disposed in spaced relationship to the inlet end of the muffler pipe. The door-halves 43 are then moved to the closed position by operation of the rollers 53 thereof on and over their companion rails 54. Power means (not shown), driven pneumatically, electrically, or the like, and which per se form no part of the invention, is intended to drive the doors 43 to and from the open and closed positions. In going to the closed position, movement of the doors 43 is synchronized whereby one of the doors moves in advance of the other door to permit the coaction and proper engagement of the elements or members 67 and 68. In going to the open position, this movement of the doors 43 is reversed.

With the tail section A of the airplane B secured in position within the enclosure and the doors 43 closed, operation of the engine sends exhaust gases and the sound waves accompanying such operation into the enclosure. The exhaust gases leaving the tail pipe of the engine are

caused to flow directly into the aligned inlet opening in the muffler pipe 42 due to the relatively high velocity thereof. This flow of the gases from the tail pipe of the airplane to the inlet duct of the muffler further causes atmospheric air to be drawn or sucked into the enclosure through the stacks 32—33 and into the stream of gases for delivery therewith into the muffler. This atmospheric air additive to the exhaust gases serves to reduce the temperature thereof in proportion to the size of the openings defined by the stacks. If there is any expansion of these exhaust gases when leaving the exhaust pipe, the muffler pipe 42 may be sufficiently larger in diameter than the engine exhaust pipe to receive the expanded gases.

Unlike the exhaust gases, the sound waves generated by the engine operation disperse immediately and the bulk thereof expands around the muffler pipe 42. These waves, therefore, strike the inner walls or sheets 25 of the composite panels 23 of the enclosure. Upon contacting the walls 25, some of these waves will pass into and through the perforations 27 in the walls 25 and be absorbed by the blanket or filler 26. The remainder of the sound waves will be deflected and due to the angular disposition of the several walls 23 of the enclosure, will be dispersed throughout the entire interior of the enclosure. This movement of the sound waves about and within the enclosure, from wall to wall, eventually results in the absorption thereof.

As above described, fresh air from atmosphere is continuously being admitted to the interior of the enclosure through the open ends of each stack 32—33. In order to prevent the escape of sound waves through these stacks, baffle means are provided in the upper portion 33 of each stack. Such baffle means may comprise a plurality of sound-absorbing attenuators 69 disposed transversely across the interior of the upper portion 33 of each stack. These attenuators 69 are fixedly secured, in any suitable manner, to the surfaces or sheets 25 of the opposite walls of the stack in aligned horizontal rows, each attenuator of adjacent rows being vertically staggered or out of alignment relative to the attenuator of the next adjacent row. Each attenuator 69 comprises a pair of perforated strips 70 having flat coplanar, transverse edges and an arcuate central portion, said strips being adapted to be disposed with their transverse edges in abutment to thereby form and define a substantially round tube. A dividing plate 71 is sandwiched between the strips 70 and secured in position by fastening means 73 passing therethrough and securing the strips 70 one to the other in a unitary assembly. Plate 71 extends the full length of the strips and serves to separate or split the tube into independent approximately semi-circular spaces in which packing or sound-proof material 26 is confined.

Some of the sound waves emanating from or generated by the engine and dispersed within the enclosure as aforesaid may enter the stacks 32—33 against the force of the down draft therein. In that event, staggered attenuators or baffles 69 are provided in each stack so that these waves will be forced against these baffles and be deflected from baffle to baffle so that, before they can reach the opening at the top of the stack, they will have been entirely absorbed by the baffles or attenuators. If desired or required, vanes or deflector plates 74 may be disposed angularly across each stack 33 at the point of mergence thereof with the interior of the central portion 39 of the enclosure.

An arcuate cover plate 75 is mounted adjacent its ends to opposite sides of each stack 32—33 at the upper or outer end thereof by one or more of the bolts 37 employed in the assembly of the chimney and securing the bands 36 thereto. Each plate 75 thereby arches and overlies the opening in its stack 32—33 and the length of each is such that it extends beyond and overhangs the adjacent sides of the stack. A space 77 is thereby created at either end of the cover 75 between the under or lower edge thereof and the upper extremity of the chimney.

Thus, while atmospheric air is free to enter each chimney through the space 77, rain, snow and other undesirable elements or objects are substantially excluded therefrom.

What is claimed is:

1. The combination with a jet engine of an airplane and a muffler, of an enclosure assembly adapted to house the exhaust end of the engine and the inlet to said muffler comprising a frame, a plurality of composite wall panels including sheets of sound-absorbing material, removable means for fixedly securing said sheets to said frame and one to another to thereby form a unitary enclosure, and removable and interchangeable means mounted on opposed sides of said enclosure each complementary to the exhaust ends of different engines and the inlet ends of the mufflers respectively for engagement therewith whereby the exhaust end of each engine and the inlet end of each muffler are so disposed that exhaust gases from the engine pass through the enclosure into the muffler and the accompanying sound waves disperse within the enclosure.
2. The combination with a jet engine of an airplane and a ground muffler, of an enclosure assembly adapted to house the aft end of the engine and the inlet to said muffler comprising a foundation, a frame removably secured to said foundation, wall panels including sheets of sound-absorbing material removably secured to and enclosing said frame, openings being provided in opposed walls of the enclosure for the reception of the aft end of the engine through one wall and the inlet of the muffler through the opposite wall, and removable means mounted in said walls and defining said openings to adapt it to receive and accommodate different engines and muffler inlets whereby the exhaust gases from the engine align with and pass into the inlet of the muffler and the accompanying sound waves disperse within the enclosure.
3. A sound-proof enclosure for coupling the aft end of a jet airplane enclosing the exhaust pipe of a jet engine to a ground muffler, said enclosure having opposed openings in its walls for the passage of the aft end of the airplane through one wall and the inlet of the muffler through the other wall, removably and replaceable means associated with the opening in said enclosure wall for the passage of the aft end of the airplane to adapt such opening to the contour and size of that part of the airplane to be situated therein, and removable means associated with the opening in the enclosure wall for the passage of the inlet of the muffler to adapt such opening to the size and contour of that part of the muffler to be situated therein, the aft end of the airplane and the inlet of the muffler being disposed within the enclosure in spaced relation whereby gases from the exhaust pipe enter the inlet of the muffler and the accompanying sound waves disperse within the enclosure.
4. An enclosure assembly to be removably anchored to a supporting surface comprising a plurality of panels of sound-proof material, means for removably connecting the adjoining edges of said panels to constitute side walls and roof of said enclosure, one side of the enclosure being open and the opposite wall thereof having an opening therein, a door associated with the open side of the enclosure, a plurality of rollers mounted on and carried by one edge of the door, a rail for cooperation with said rollers to support the door, guide means at the opposite edge of the door to control the position and movement of the door relative to the enclosure, an acoustic seal operative between the edges of the door and the walls and roof of the enclosure, removable means carried by the door to engage a unit partially housed within and projecting from the enclosure, and removable means associated with said wall opening to engage a unit received in such opening and projecting on both sides of the wall defining said opening, whereby the adjacent ends of said units are disposed within the enclosure in spaced relationship one to the other.

5. An enclosure comprising a frame constructed by a plurality of removably interconnected beams, anchoring means to removably secure said frame to a supporting surface, wall panels including sound-absorbing material disposed within and filling the space between adjacent beams to thereby enclose the sides, roof and one end wall of the frame, the opposed end of the enclosure being open and the end wall having an opening therein, removable and exchangeable means connected to said end wall to adapt the opening therein to the size and contour of a unit passing through said opening and projecting on both sides of said end wall, releasable means securing adjacent panels one to the other and to the beams of the frame, at least one inlet stack to admit external air to the enclosure, a door assembly including sound-absorbing material mounted for movement on the open end of the enclosure, said door having an opening therein in general alignment when closed with the opening in the end wall, and removable and exchangeable means mounted on the door assembly to adapt the opening therein to the size and contour of a unit partially housed within the enclosure and disposed to pass through and project beyond the door assembly when closed.

6. A sound-proof enclosure comprising a frame consisting of a plurality of removably interconnected beams including an upright extension to define an air inlet stack, anchoring means to removably secure said frame to a supporting surface, a plurality of wall panels each including sound-absorbing material enclosing each stack and all sides but one of the frame to thereby form an enclosure having one side open, an opening in the wall opposed to said open side, releasable means fixedly connecting the wall panels one to the other and to the frame, sound-absorbing baffles disposed within each stack, a door assembly fabricated of sound-absorbing material and mounted on the enclosure adjacent the open side thereof for movement to and from open and closed positions to admit the aft end of an airplane housing the exhaust pipe of a jet engine thereof into the enclosure, said door assembly being formed to engage said aft end when disposed in the closed position, means removably connected to the door assembly to adapt it to conform to a selected range of sizes and shapes of such aft ends, and means connected to the wall of the enclosure opposite the open side thereof to permit the reception and engagement of the inlet duct of a ground muffler whereby the adjacent ends of said exhaust pipe and said inlet duct are both disposed within the enclosure in alignment.

7. A dismantlable enclosure to couple the tail section of an airplane to the inlet of a ground muffler comprising a plurality of removably interconnected beams combining to form a frame defining a substantially rectangular main portion, means to releasably secure said frame to a stationary supporting surface, an extension frame projecting outwardly from and upwardly of one side of said main portion and a stack projecting upwardly from each end of said main portion, wall panels of sound-absorbing material enclosing the area defined by the beams of said main portion, said extension frame and the sides of said stacks to thereby form an enclosure with one side open, an aperture in the wall opposite to said open side, sound-absorbing baffles secured to the walls of each stack, attachment means to removably secure the wall sections one to the other and to the frame, a pair of door halves each fabricated of sound-absorbing material and mounted on the enclosure adjacent the outer edge of said extension frame for movement toward and away from each other to thereby coact in opening and closing the open side of the enclosure, the adjacent edge portions of said door halves including complementary removable and exchangeable sections for cooperation one with the other to define an opening which conforms in size and shape to that of the aft end of an airplane to be engaged thereby and received therein, and removable

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and exchangeable means connected to the wall of the enclosure having an aperture therein to adapt said aperture for reception and engagement of the inlet of a muffler corresponding in size and shape to the engaged airplane.

8. A sound-proof enclosure comprising a frame assembly organized and arranged to define in plan a substantially rectangular main portion, a vertical stack at each end of such main portion, a peaked roof for said main portion disposed centrally between said stacks, an extension projecting from a corresponding side of each stack, said extensions converging in a peak disposed in the place of said peaked roof to thereby form a continuation thereof, wall panels secured to the frame assembly to enclose the sides thereof, each such panel consisting of an imperforate outer sheet and a perforated inner sheet separated by an interlayer of sound-absorbing material, a pair of generally triangular door frames mounted on said frame assembly for sliding movement relative to said extension to and from a position where their adjacent edges abut in vertical alignment with the outer end of the aforesaid peak, said edges being recessed medially of their length for cooperation one with the other to define an opening to receive and engage the aft end of an airplane housing the exhaust pipe of its engine, door panels constructed like said wall panels secured to and enclosing said door frames, and an aperture piercing the wall panel of said main portion in opposition to said door halves when disposed in the abutting position to align with said opening therein for the reception and engagement of the inlet to a ground muffler.

9. A sound-proof enclosure for use in warming up jet engines comprising enclosing walls, two opposite walls of which have aligned openings for the reception of the discharge end of a jet engine and a muffler, respectively, the walls of said enclosure being of the sound-absorbing type, and at least one substantially vertical stack opening internally of and extending externally from said enclosure, said stack having sound-attenuating means associated therewith.

10. An enclosure as set forth in claim 9 in which each of the enclosing walls is disposed in a plane angular to

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every other wall whereby sound waves striking said walls are deflected.

11. An enclosure as set forth in claim 9 in which the enclosing walls include a pair of sloping side walls interconnected at their upper edges to form a peaked roof with the rear edges of said side walls disposed in a common transverse plane and the forward edges of said side walls disposed at an acute angle relative to said transverse plane to terminate forwardly in a substantial point, and vertically disposed end walls in substantially edge to edge abutting contact with the rear and forward edges aforesaid.

12. An enclosure as set forth in claim 9 in which the enclosing walls include a triangular upstanding rear wall, a pair of generally right triangular side walls disposed with their base edges in abutment with and at substantial right angles to each upstanding edge of said rear wall and their adjacent side edges disposed in abutment in the plane of the apex of said rear wall to thereby create a peaked roof terminating forwardly in a point, and a pair of slidably mounted vertically disposed frontal walls one associated with each diagonal edge of said triangular side walls, said frontal walls being adapted to be located in positions with adjacent edges in abutment closing the enclosure and adjacent edges spaced permitting access internally of the enclosure.

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